UK Forestry Standard **Practice Guide** Second edition

Managing forest operations to protect the water environment

Forestry Commission
Scottish Forestry
Coilltearachd na h-Alba
Cyfoeth Naturiol Cymru
Natural Resources Wales
Forest Service
An tSeirbhís Foraoisí

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Enquiries relating to this publication should be addressed to:

Forest Research
Alice Holt Lodge
Farnham GU10 4LH
publications@forestresearch.gov.uk

Technical author contact:

Dr Tom Nisbet
Forest Research
Alice Holt Lodge
Farnham GU10 4LH
tom.nisbet@forestresearch.gov.uk

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Introduction

The environmental benefits provided by forests and woodlands are increasingly recognised and valued by society. Benefits for the water environment include the ability of woodlands and trees to protect aquatic habitats and species, preserve the quality of drinking water, alleviate flooding, and guard against erosion, landslides, and the loss of soil. The provision of such benefits is central to public funding for woodland creation and management. It is therefore essential that we manage our forests sustainably to protect the environmental goods and services they provide.

Many forest management practices can impact on the water environment as a result of soil and vegetation disturbance or through the alteration of the pathways of water movement. Poor forest management can diminish or reverse the benefits provided by forests and woodlands, contribute to local flooding, and risk severe water pollution (e.g. by increasing sediment run-off and water turbidity). Although larger-scale forest operations generally pose the greatest risk, small-scale working can also cause significant water problems.

The UK governments' requirements for sustainable forest management are set out in the UK Forestry Standard (UKFS). The UKFS Guidelines on Forests and Water describe how to comply with the requirements in order to protect the water environment. They form the basis for assessing forest management activities to ensure that there are no detrimental effects on water, both within the forest and downstream. The UKFS promotes an integrated catchment management approach and lays particular emphasis on riparian buffer areas and their role in protecting water.

Aim and scope

This Practice Guide provides detailed supplementary guidance to forest managers, practitioners, planners, and supervisors on how forest operations should be planned and managed to protect the water environment. The Guide is structured by forest operation. Each section starts with a summary of the most relevant water issues followed by subsections that set out guidance on planning and operational practice. A summary of the main points is provided for those working on forest sites using illustrated examples of forestry practice situations. Applying this guidance will help ensure that forest operations comply with the UKFS Guidelines on Forests and Water, which are the primary source of information on the legal and good practice requirements.

> ! It is the responsibility of forest owners and managers to identify and apply the UKFS Guidelines that are appropriate to their particular forest or woodland situation.

This Second Edition has been published to align the guidance provided with the 5th edition of the UK Forestry Standard.

Forest operations and planning

Forest operations must be planned in advance of work starting on the site. Operational planning is concerned with the detail of how most forest management activities will be implemented at site level, within the framework of a forest management plan. This includes, for example, details of working methods, any areas to be protected, and the location of timber stacks and storage areas. Contingency plans should also be drawn up to ensure that procedures are in place and can be enacted should unforeseen events such as accidental spillages or fires occur. Operational and contingency plans should be drawn up by suitably trained staff.

Forest workers and machine operators must be aware of and understand the requirements of the operational and contingency plans and be competent to implement these. A site meeting prior to starting work is the best way to explain any special working instructions and operational detail. A particularly important consideration in relation to the water environment is to think through how operations will be affected in the event of very wet weather. All aspects of site operations will need to be reviewed – and possibly modified or suspended – when weather or ground conditions deteriorate, a decision that will often need to be taken on the day.

Buffer areas

Buffer areas are designed to protect the water environment from forestry activities and their use is central to this guidance. Forest operations within buffer areas should be limited to hinge or inverted mounding and the direct planting of native trees and shrubs and other ecologically appropriate broadleaved trees to create riparian woodland (Table 1). However, mounding should stop within 2 m of watercourses and within 5 m of abstraction points for water supply; note that this is a legal requirement in Scotland.

Buffer area guidance applies equally to new planting and forest restocking. Creating buffer areas is more demanding on restock sites where existing drains are directly connected to streams and thus form watercourses. Redesigning or blocking drains to create an intact buffer is particularly problematic on very gently sloping or flat ground due to the resulting backing up of surface water. Efforts here should focus on converting such waterlogged ground into wet woodland or open wetland habitat, which can form a very effective buffer for management activities on adjacent upslope areas.

These buffer widths and precautions apply on both sides of the watercourse and around the whole perimeter of the waterbody, and apply to all waterbodies, including connected ditches and drains, wetlands, large ponds, lakes, and reservoirs. Ditches and drains that are disconnected from a watercourse and so do not carry water into them do not require a buffer area.

The minimum buffer widths, or minimum working distances, given in Table 1 are recommended as part of the Good Practice Requirements of the UKFS, but wider buffer areas might be required by a regulatory body as a condition of consent or permit (and this might be to address other interests such as a nearby priority habitat, private water supply, designated site or historic environment feature).

Narrower widths of buffer area might be appropriate along minor watercourses with a channel less than 1 m wide, especially on steep ground. The UKFS takes this pragmatic approach for minor watercourses to accommodate situations where, on the one hand, they could be valuable habitats such as spawning streams, but in other situations they may be ephemeral drains leading to a watercourse.

Table 1 Minimum buffer widths for forestry activities (except those listed above in text) from forest edge to watercourse, waterbody, or abstraction point.

Buffer width	Situation
10 m	Along permanent watercourses with a channel less than 2 m wide.
20 m	Along watercourses with a channel more than 2 m wide and along the edge of lakes, reservoirs, large ponds, and wetlands.
50 m	Around abstraction points for public or private water supply, such as springs, wells, boreholes, and surface water intakes.

1. Cultivation

Cultivation is usually the first operation carried out to prepare a site for planting. The aim is to create favourable growing conditions for new transplants by loosening compacted soil, reducing weed competition and creating a raised planting position. However, it can also have a number of impacts on the water environment. The primary issue is that soil disturbance and trafficking by cultivation machinery can accelerate run-off and lead to the erosion and washout of soil material into watercourses. Faster run-off can increase peak flows, while the resulting sediment can cause water turbidity and siltation. The risk is greatest where cultivation methods produce long linear channels that can concentrate and direct run-off (Figure 1). A secondary issue is the potential for cultivation to increase the loss of soil nutrients such as phosphate and nitrate (attached to soil particles or dissolved in run-off) to watercourses. Cultivation can also increase the release of dissolved organic carbon, which can affect water colour.

> **!**
> The more extensive, continuous, and deeper the soil disturbance during cultivation, the greater the risk of erosion and soil wash-off. The resulting sediment can cause serious water pollution over considerable distances.

Key planning and operational measures to protect the water environment are set out below. Good practice for operators is illustrated on page 6.

Figure 1 Long linear cultivation channels on sloping sites such as this can generate significant run-off and sediment, with the potential to breach buffer areas and pollute watercourses.

Planning cultivation operations

An operational plan is required before any cultivation work starts on site. The plan should be informed by the UKFS and the Forestry Commission Bulletin *Cultivation of soils for forestry*. The aim should be to cause the least soil disturbance possible, particularly on organic soils, while meeting cultivation objectives in terms of tree establishment and growth. Land must be cultivated and run-off discharged in such a way that minimises the risk of pollution to the water environment and the potential impact on downstream flooding.

Key points for planning are:

- Assess the site and select the most appropriate cultivation technique(s), cultivation depth, and width of buffer to match conditions. Consider the risk of soil erosion (Box 1 and Figure 2) and any other environmental sensitivities, including the vulnerability of downstream water users.

Box 1 Determining soil erodibility

Soil erodibility is primarily determined by soil texture, soil structure, slope, run-off, and vegetation cover. The presence of bare ground, coarse mineral soil textures (sand, loamy sand, and sandy loam), amorphous peat soils, poorly structured and cohesionless mineral soils, steep slopes, and high surface run-off all increase the risk of erosion. Soil cultivation has the potential to accelerate erosion by removing vegetation, capturing and channelling run-off, and potentially exposing deeper and more erodible soil material. Some types of clay deposits are particularly sensitive to disturbance, generating very fine sediment that can cause serious water pollution. However, cultivation can also reduce the risk of erosion by improving soil structure, such as by breaking up compacted surface layers or soil pans allowing water to percolate and thereby reducing the speed and volume of surface run-off. Maps are available for some parts of the UK classifying the susceptibility of soils to erosion (search for the erosion risk map at **www.data.gov.uk**).

- Do not create linear cultivation channels or subsoil on steep slopes (>18º); moderate slopes (>11º) with medium or highly erodable soils; and gentle slopes (>6º) with highly erodable soils. Plan to use excavator or continuous mounding (Figure 2), patch scarification or screefing instead.
- Do not create linear cultivation channels over large areas where there is a high risk of downstream flooding (Figure 3).
- Take particular care on sites with intimate soil complexes, especially where these present a significant erosion risk.
- Plan adequate buffer areas to protect watercourses and public or private water supplies. Do not use a wider buffer in place of a less appropriate cultivation technique in the hope that any eroded sediment can be managed in this way.
- Plan to install drains at the same time or immediately after cultivation operations.
- Plan cultivation for restocking before harvesting begins so that the distribution and alignment of brash is suited to site conditions.
- Incorporate wet flushes and associated waterlogged/boggy ground into buffer areas, particularly within valley bottoms.
- Plan ahead for changes in the weather that could affect site conditions.

Figure 2 Mounding results in much less soil disturbance compared with ploughing, reducing the risk of erosion and sediment run-off.

Figure 3 An example of inappropriate ploughing (e.g. absence of furrow breaks at cross-drains) over a large area with insufficient measures to control rapid run-off.

Operational practice

Operational practice should always adhere to the plan. It is essential that machine operators and all those working on site are fully aware of the detail of the plan and closely follow any specifications set out there. The general condition of water flowing from a site should be monitored throughout operations (see Monitoring on page 42 for more information).

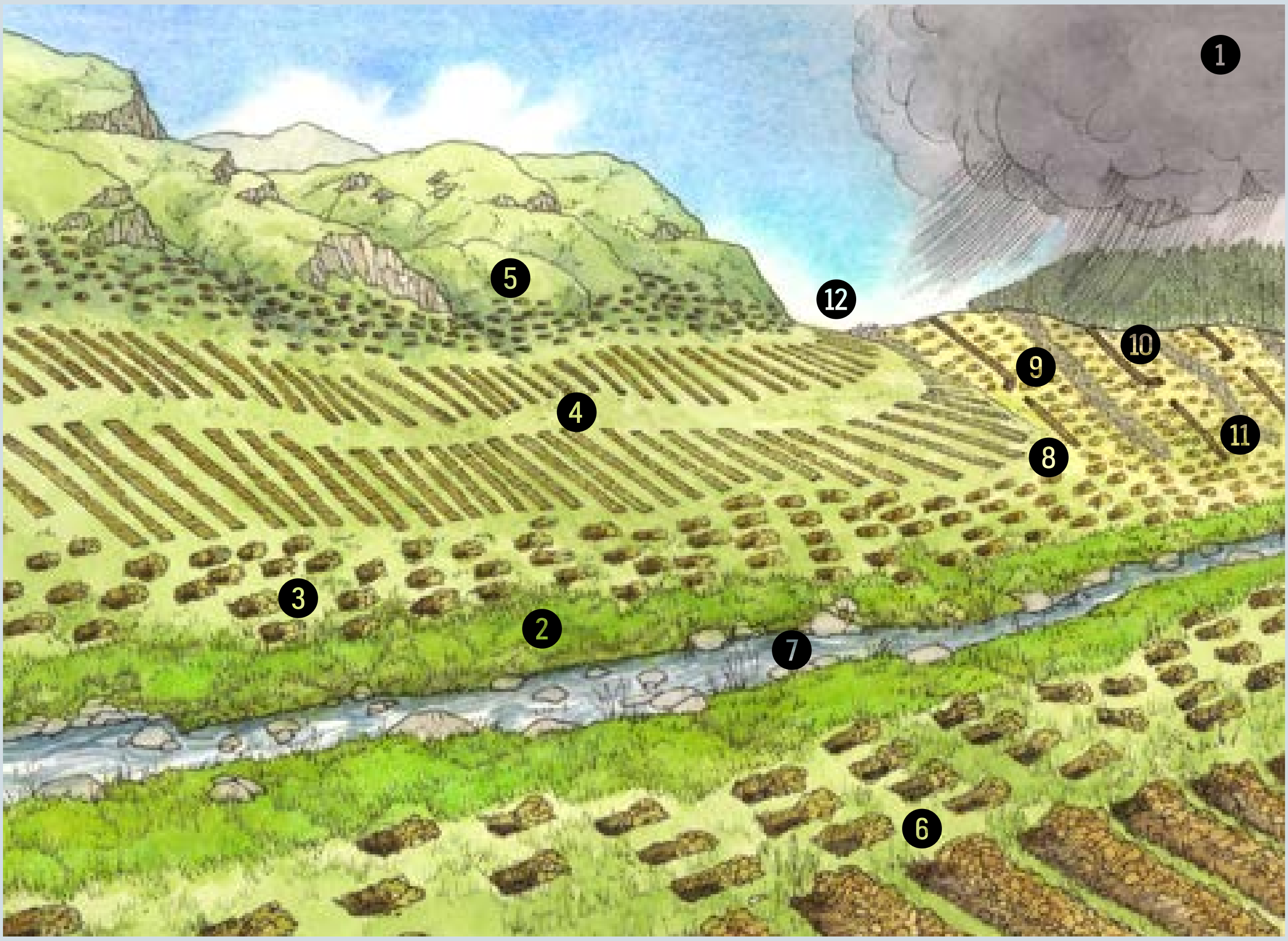
Key points for managers of cultivation operations are to ensure that:

- Excessive soil disturbance is avoided (Figure 4).
- 2–5 m wide breaks are left along linear cultivation channels (and any associated subsoiling) at regular intervals on moderate (e.g. every 40 m) and gentle (e.g. every 70 m) slopes.
- Tine slots or rip lines do not intercept and carry significant water flow from relic drains, springs or cross-drains (Figure 5).
- Existing tile and stone drains are not disrupted where these work effectively and are not causing any sediment issues.
- The length of spoil trenches on restock sites is restricted to 30 m or less. Where this is not possible, incorporate trenches into the formal drainage system – ensuring trenches meet limits on drain gradient.
- On long sloping sites, consecutive lengths of spoil trench are offset to ensure that water does not flow directly from one trench into another; alternatively, spoil trenches are terminated with alternating, tapered, angled exits for the last 2 m.
- Trenches do not intercept or discharge directly into springs or existing connected drains.
- Fresh brash is not mulched (broken/chipped and/or incorporated/mixed with the soil) on sites draining to waterbodies that are sensitive to nutrient enrichment or acidification.
- Operations are adapted or suspended if weather or ground conditions deteriorate.

Figure 4 Excessive soil disturbance can lead to sediment-laden run-off and should be avoided. It isn't enough to rely on buffer areas to protect watercourses.

Figure 5 Shallow ploughing and use of a tine on this new planting site will relieve compaction and aid water infiltration. The short furrows and shallow cultivation minimise the risk of erosion.

1. Protecting the water environment from cultivation operations



1. Consider the weather and aim to carry out cultivation operations during dry periods.
2. Do not cultivate ground within 2 m of a watercourse or 5 m of abstraction points for water supply, such as springs, wells, boreholes and surface water intakes.
3. Limit cultivation to hinge or inverted mounding within buffer areas.
4. Leave 2–5 m breaks in plough lines (and any associated subsoiling) at regular intervals (e.g. every 40 m on moderate slopes and every 70 m on gentle slopes).
5. Only use discontinuous forms of cultivation on steep slopes.
6. Restrict the depth of ploughing (e.g. to 30 cm) to reduce soil disturbance.
7. Avoid fording streams and rivers, unless there is an existing purpose-built ford.
8. Do not dig spoil trenches that can discharge directly into watercourses.
9. Orientate spoil trenches so that they cannot intercept or carry large volumes of water; turn out the bottom 2 m length of each trench to alternate sides to dissipate flows.
10. Do not fill trenches created for mounding with fresh brash.
11. Restrict the length of trenches to less than 30 m; if this is not possible, fully integrate trenches into the drainage system – do not exceed 2° gradient limit.
12. Install drains at the same time or immediately after cultivation operations.

2. Drainage

Drainage is used to improve the productivity of planted forests on poorly drained sites where excessively wet soil conditions limit tree growth and access for harvesting and other management activities. However, inappropriate or poorly designed drainage systems can negatively impact on water flows and on the wider freshwater environment. The main issue relates to drains speeding up or diverting surface run-off, which can increase erosion (Figure 6) and the siltation of watercourses. It can also promote landslips and debris flows, and affect downstream flood risk.

Figure 6 Excessive run-off has caused major erosion and gullying within this drain.

Key planning and operational measures to protect the water environment are set out below. Good practice for operators is illustrated on page 10.

Planning drainage operations

An operational plan is required before any drainage work starts on site. The plan should be informed by the UKFS Guidelines on Forests and Water and consider on-site and off-site factors and the wider water catchment. The aim should be to minimise both the risk of erosion and washout of sediment into watercourses, as well as the impact of drainage on flood flows. Any deficiencies in existing forest drainage systems should be identified and rectified when opportunities present themselves, such as at restocking.

> **!** Check to see if there are any local properties or assets at risk of flooding. If so, consider the contribution of planned drainage works and whether amendments to the proposals are needed.

Key points for planning drainage operations in new planting and restocking situations are:

For new planting

- Assess the site using soil maps, detailed topographic data, and information on planned cultivation to identify drainage needs.
- Assess the layout and condition of any existing drainage system; and plan any restoration work to reduce the risk of erosion and sediment run-off.
- Plan the drain layout in relation to pathways of water movement, existing drains, and local watercourses, starting with cut-off drains and then cross-drains.
- Operations are adapted or suspended if weather or ground conditions deteriorate.

- Avoid creating drains on steep (>18°) slopes and moderate (11–18°) slopes with medium or highly erodible soils.
- Plan adequate buffer areas to protect watercourses and vulnerable habitats/species.
- Cut off any existing open drains that do not adhere to the UKFS Guidelines on Forests and Water and ensure that diverted flows are appropriately managed and do not bypass buffer areas.
- Design the length and spacing of cross-drains to control the volume of run-off so that it does not exceed the capacity of the drainage system.
- Design drains to discharge water to flatter areas to enable flows to fan out and slow down.
- Reduce the drain gradient on highly erodible soils to less than <2° and increase the recommended widths of buffer areas.
- Avoid drains discharging directly into watercourses (Figure 7).
- Never divert significant volumes of water from one catchment to another.
- Avoid drains discharging onto neighbouring land, unless by agreement.
- Keep forest drains and road drains separate: do not discharge water into road drains.
- Plan to install drains at the same time or as soon as possible after cultivation operations, especially where run-off could reach and overload road drains.
- Plan ahead for changes in the weather that could affect site conditions.

For restocking

- Assess the condition of the existing drainage system.
- Identify and assess watercourses (including any that are dry/redundant).
- Redesign the drainage system to correct any problems such as drains discharging directly into watercourses (Figure 8).
- Only infill drains to create a buffer area where drain flows are manageable and unlikely to washout the fill; otherwise redesign the drainage system.
- Where a drain has become a main watercourse and is not subject to erosion problems, treat it as a natural watercourse and create a buffer area along its length (Box 2).
- Seek hydrological advice where drainage is contributing to major gullying and erosion (Figure 6).
- Avoid redraining wet hollows and flushes in valley bottoms and instead convert them to open glades or wet woodland.

Figure 7 Avoid drains such as this one continuing to discharge directly into watercourses.

Figure 8 An example of a well-designed cut-off drain controlling restock site run-off.

Box 2 Discriminating between drains and natural watercourses

It is important to discriminate between drains and natural watercourses when deciding whether to intervene to disconnect a drain and amend a drainage system. In some cases this is made difficult by drains taking on some of the features of natural watercourses over time, usually as a result of carrying too much water. The main differences are as follows (if in doubt, seek advice from the local water regulatory authority):

- Drains (left) are generally straight, have a relatively even bed gradient and often an unnatural alignment, such as cutting across a slope. They may have taken on some of the features of a natural watercourse if they have become overloaded and flows have enhanced bed or bank erosion. Where this happens, efforts should focus on reducing discharge volumes by installing cut-off drains upslope, especially where erosion is marked and active.
- Natural watercourses (right) generally have a meandering or stepped profile, often comprising a series of pools separated by shallower, faster flowing sections over gravel or rock, and are usually contained within a distinct valley, although this will usually be relatively shallow close to the source. Although they may be straightened as a result of drainage works, they will still lie within a valley bottom or floodplain, which may contain relic meanders or other features.

Forest drains tend to be straight and relatively smooth, with shallow water flow.

Natural watercourses generally bend and have a more varied structure.

Operational practice

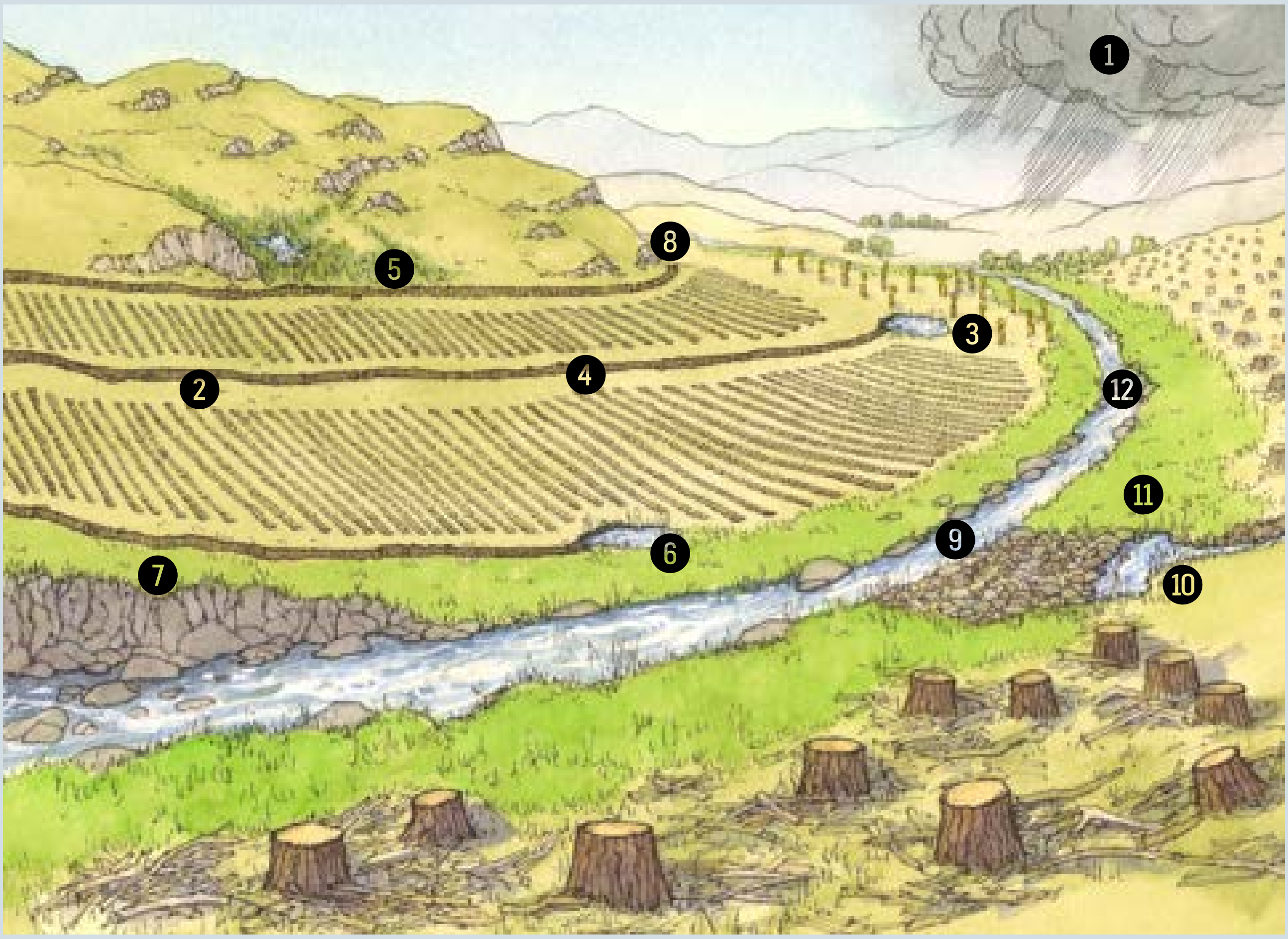
Operational practice should always adhere to the plan. It is essential that machine operators and all those working on site are fully aware of the detail of the plan and closely follow any specifications set out there. The general condition of water flowing from a site should be monitored throughout operations (see Monitoring on page 42 for more information).

Key points for managers of drainage operations are to ensure that:

- Drain lines are pegged out in the field prior to drainage operations and a clinometer is being used to check that drain gradients do not exceed guidelines.
- Drain gradients are maintained across minor undulations to avoid the formation of hollows where water could overspill and discharge down cultivation channels.
- Drains are ended in shallow turnouts that act as small silt traps.
- Drains are not discharging onto unstable slopes or destabilising the banks of watercourses.
- Mole drains are directly connected into cross-drains to avoid waterlogging; on clayey soils this means mole drain outlets may need to be opened out with a stick or spade.
- Drains are not retrofitted unless absolutely necessary.

!

Confine drain maintenance to drier periods (ideally May–October); take particular care where drains remain connected to watercourses. If necessary seek advice from the local water regulatory authority or fishery body.



1. Consider the weather and aim to carry out drainage works (including drain maintenance and silt trap cleaning) during dry periods.
2. Cut drains to run at an even gradient of 2° (3.5%) or less leading towards the head of the valley; ensure water does not discharge into lower cultivation channels.
3. End drains in a shallow turnout.
4. Space drains so that the volume of run-off does not exceed the capacity of the drainage system.
5. Provide 'cut-off' drains so that plough furrows do not carry significant volumes of water from wet areas above.
6. Stop drains at the edge of buffer areas, preferably on flat ground where water can fan out.
7. Ensure drains do not discharge to the edges of steep gully sides or unstable slopes.
8. Avoid drains diverting water to adjacent catchments.
9. Do not end drains in natural channels, ephemeral streams or old agricultural drains.
10. Redesign existing drainage systems to meet current standards and correct any erosion problems; ensure drains discharge to a minimum 10 m wide buffer area along permanent watercourses with a channel <2 m wide, and to a minimum 20 m wide buffer area along channels >2 m wide. Note that narrower buffer widths (minimum 5 m) might apply along channels <1 m wide, especially ephemeral watercourses on steep ground.
11. Where an existing drain has become a sizeable and stable watercourse, treat as a natural watercourse and establish buffer areas along its length; if in doubt, seek advice.
12. Avoid fording streams and rivers, unless there is an existing purpose-built ford.

3. Fertilisers

Fertiliser is not usually required in any quantity in forestry, and applications are confined to particular nutrient-poor sites where deficiencies can occur – for example, on reclaimed land and in some upland situations. However, with any application of fertiliser, there is the potential for the applied nutrients to be leached out and washed off, polluting watercourses and water supplies. This is particularly the case for aerial applications, which will treat cultivation channels and drains as well as creating the risk of fertiliser drift onto buffer areas and watercourses.

Standing waters such as lakes and reservoirs are especially vulnerable to nutrient enrichment, which can degrade water quality and cause unwelcome ecological changes such as algal growth (Figure 9). The effects of nutrient enrichment can continue for a number of years after a fertiliser is applied and it is important to allow for this when planning multiple treatments in large forested catchments.

Key planning and operational measures to protect the water environment are set out below. Good practice for operators is illustrated on page 14.

> **!**
> The wash-off of applied nutrients is bad for the water environment and those that use water. It can cause water pollution and toxic algal blooms that could result in prosecution.

Figure 9 Phosphate run-off can result in toxic algal blooms that can be fatal to wildlife and pets.

Planning fertiliser applications

It is important that the use of fertilisers is well planned. A detailed operational plan is required before any fertilisers are applied on site. The aim should be to minimise the washout or leaching of nutrients and the risk of pollution to the freshwater environment.

Key points for planning fertiliser applications are:

- Survey the site to delineate the treatment area and map buffer areas around all surface water features (including watercourses, drains acting as/connected to watercourses, flushes, and areas of boggy ground).
- Use the site map to identify safe temporary storage and fertiliser handling areas.

Aerial applications require special planning considerations. Key points for planning are:

- Check whether the site drains to a nutrient-sensitive water body (Box 3).
- Double the minimum width of recommended buffer areas for aerial applications to land draining to nutrient-sensitive waters.
- Avoid aerial applications to private water supply catchments.
- Use coordinates taken from the mapped buffer areas to guide aerial applications (Figure 10).
- Plan ahead for changes in the weather that could affect site conditions and fertiliser drift.

Box 3 Nutrient-sensitive waters

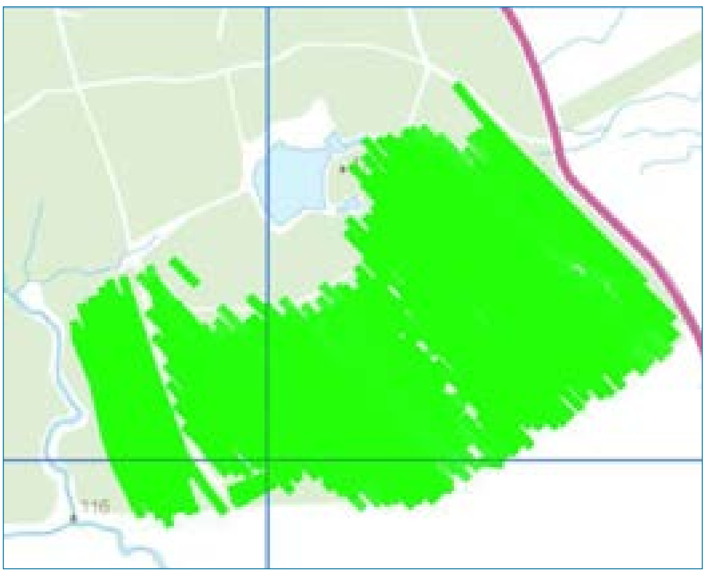
Nutrient-sensitive waters are particularly vulnerable to phosphate and/or nitrogen (nitrate or ammonium) run-off from fertiliser applications. These waters comprise:

- River and lake water bodies that are failing Good Status due to nutrient pollution.
- Water bodies supporting freshwater protected and priority species and habitats that are vulnerable to nutrient enrichment.
- Public and private water supplies.
- Shallow coastal water bodies designated for shellfish and vulnerable to nitrogen enrichment.

Early consultation with appropriate organisations will help to determine if a planned aerial fertiliser application is on land draining to nutrient-sensitive waters. Contact the water regulatory authority about the status and sensitivity of downstream water bodies to nutrient run-off, including coastal waters. Conservation agencies will be able to advise on the vulnerability of protected and priority freshwater species and habitats to nutrient enrichment, while a check with water companies will determine the presence of any public water supplies.

Private water supplies can be more difficult to locate and best checked with the local authority environmental health department, land occupiers and their neighbours. Private water supplies often comprise springs or streams draining small catchment areas, making them particularly vulnerable to contamination.

Figure 10 This spread pattern recorded by a helicopter guidance system shows that the use of map coordinates to guide aerial fertiliser application can reduce the risk of treating buffer areas.



Operational practice

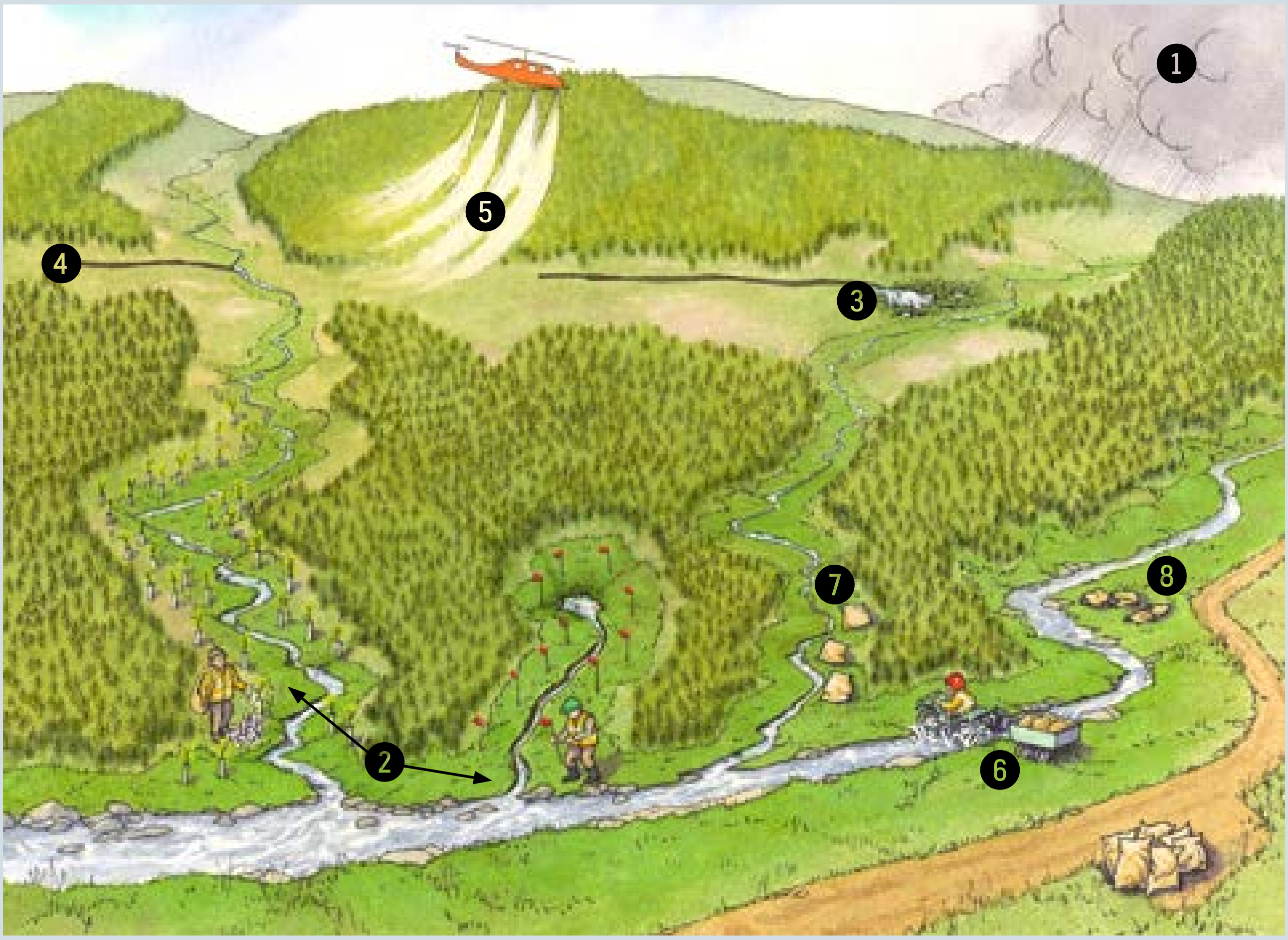
Operational practice should always adhere to the plan. It is essential that machine operators and all those working on site are fully aware of the detail of the plan and closely follow any specifications set out there.

Key points for managers of fertiliser operations are to ensure that:

- Appropriate areas for fertiliser treatment, safe sites for temporary storage and handling, and suitable access points are clearly marked out on the ground (Figure 11).
- Buffer areas are respected and fertilisers are not being applied to any watercourse.
- Hand applications avoid treating cultivation channels and drains.
- Fertilisers are only applied when weather conditions are suitable. This means avoiding periods of wet weather (or if heavy rain is forecast within 48 hours) and windy conditions (more than a light breeze).
- Fertilisers are only applied when ground conditions are suitable. This means avoiding ground that is frozen, waterlogged, snow-covered, actively eroding, or baked dry after drought (and rain is forecast).
- Fertilisers are not being applied when drain flows are sufficient to produce surface run-off across buffer areas.
- Any equipment used in fertiliser applications is well maintained and in a good state of repair.
- Care is taken when distributing fertiliser bags around a site.
- Empty fertiliser bags and unused fertiliser are removed from the site.
- Operations are suspended if changes in the weather could affect site conditions and fertiliser drift.

Figure 11 Fertiliser should not be stored within buffer areas as rivers can flood and washout fertiliser bags.

3. Protecting the water environment from fertiliser applications



1. Do not apply fertiliser during wet weather (or if heavy rain is forecast within 48 hours), if wind conditions are inappropriate, or if the ground is waterlogged, frozen, or snow-covered.
2. Do not apply inorganic or organic fertiliser within buffer areas, regardless of method or form of fertiliser; make sure the buffer area is clearly marked.
3. Do not apply fertiliser when run-off from drains is sufficient to produce visible surface flow across buffer areas.
4. Treat drains that have become sizeable and stable watercourses and those that flow directly into streams (including road drains) as natural watercourses with their own buffer areas.
5. Double minimum buffer widths for aerial fertiliser applications to land draining to nutrient-sensitive waters.
6. Do not ford streams with loaded quads or other vehicles when distributing fertiliser bags or other materials around a site.
7. Do not store fertiliser within buffer areas.
8. Do not bury or leave empty fertiliser bags on site.

4. Pesticides

Herbicide is the most commonly used pesticide in forestry as it can be a cost-effective means of controlling weeds in planted forests (Figure 12). However, treatments involving herbicide and other pesticides such as fungicides or insecticides can pollute the freshwater environment and water supplies, even in extremely low concentrations. Accidental spillage of undiluted pesticide probably poses the greatest risk of water pollution. Most pesticides are highly mobile in water and extremely difficult to track and remove; contaminated water can be damaging to freshwater life over considerable distances downstream.

Non-chemical approaches exist for many weed problems, and these should always be considered before resorting to the use of pesticides. Only if all the possible non-chemical control options have been considered and rejected as impractical, ineffective, or potentially harmful, should the use of pesticides be considered. Their use should be minimised in line with the UKFS and other relevant good practice guidance (see 'Further reading and useful sources of information').

Key planning and operational measures to protect the water environment are set out below. Good practice for operators is illustrated on page 18.

Figure 12 Bracken can swamp young trees and compete with them for light, moisture and nutrients. It often needs to be surpressed to allow trees to establish successfully.

Planning pesticide applications

It is vital that pesticide operations are well planned. Pesticide users are legally responsible to apply, store, and dispose of pesticides safely, taking appropriate care to ensure that working practices do not contaminate water and the wider environment. A detailed operational plan is required before any herbicides, fungicides, or insecticides are applied on site. A contingency plan that sets out the action that must be taken in the event of an accidental spillage should be drawn up and made available to all operational staff (see Section 8). Aerial application of pesticides is a special case not covered by this Practice Guide (see Box 4).

> **!** Contamination of water by pesticides can be extremely damaging to freshwater life over considerable distances downstream and have serious implications for water supplies.

Key points for planning are:

- Survey the site to identify and delineate the treatment area and clearly map buffer areas around all surface water features, including watercourses, ponds, lakes, reservoirs, water

The use of pesticides is not permitted within buffer areas except for products that are approved for use in or near water. The use of these may require formal consent from the water regulatory authority.

supply abstraction points, drains acting as or connected to watercourses, flushes, and adjacent boggy ground.

- Ensure that the minimum buffer width for the use of pesticides along minor watercourses (with channels <1 m wide) is 10 m, within which the preparation and spraying of pesticides, cleaning of equipment, disposal of washings, and the planting of treated trees is excluded.
- Consult with the relevant water authority and users of private water supplies where a proposed application is on land draining to these supplies.
- Use the site map to identify safe temporary storage, handling and washdown areas (e.g. level ground outside of buffer areas), suitable access points, and watercourse crossings.
- Select the pesticide with the lowest hazard rating to aquatic life where there is a choice.
- Ensure all pesticide users are trained to the required standard.
- Prepare a detailed contingency plan to deal with accidental spillage informed by advice from the water regulatory authority.
- Ensure operators are trained in implementing the contingency plan and in the use of spill kits (Figure 13; see also Section 8).
- Seek advice from the waste regulatory authority about the safe disposal of unwanted pesticides.
- Plan to pause, adjust, or abandon spraying if the weather changes suddenly.

Box 4 Aerial applications of pesticide in the UK

The use of aerial spraying in UK forestry is an extremely rare occurrence and the only likely uses are for controlling bracken on extensive upland areas (where ground access is very difficult), or for the use of a specific insecticide or fungicide that may have been granted emergency approval by the Chemicals Regulation Directorate (e.g. to deal with a potentially catastrophic outbreak of a particular pest or disease). Products can only be used if they have specific approval for aerial spraying, if spraying is carried out in line with an approved Application Plan, and if the specific spray operations have been permitted by the Chemicals Regulation Directorate. A number of additional legal obligations must also be fulfilled before and during any spray operation, including taking reasonable precautions to protect human health and the environment.
Full details of the revised arrangements for aerial spraying are contained on the Chemical Regulation Directorate's website (www.pesticides.gov.uk). In addition to their legal obligations, it is recommended that anyone contemplating a programme of aerial spraying against pest or disease outbreaks in forestry situations should contact the relevant forestry authority for advice.

Operational practice

Operational practice should always adhere to the plan. It is essential that machine operators and all those working on site are fully aware of the detail of the plan and closely follow any specifications set out in it. For pesticide operations, practice should be informed by the appropriate code of practice. It is particularly important that pesticides are applied in accordance with the product label (see Further reading and useful sources of information).

Key steps to consider when managing pesticide applications are to ensure that:

- Appropriate areas for pesticide treatment, safe sites for temporary storage and handling, and suitable access points are clearly marked out on the ground.
- Pesticides are not applied in buffer areas unless the product is approved for use in or near water. Such products include the use of plant protection products for the sole purpose of controlling an invasive species of plant outwith its native range. The use of such products may require appropriate consent from the relevant water authority and must adhere to the specific guidance on their use.
- Containers of pesticide concentrates are safely stored outside of buffer areas.
- Staff and contractors are supervised and are fully complying with pesticide label instructions.
- Treated trees are not planted within buffer areas.
- Treated planting stock is kept out of watercourses and drains, even if water stressed.
- Pesticides are only applied when weather conditions are suitable. This means avoiding periods of wet weather (or if heavy rain is forecast within 48 hours) and windy conditions (more than a light breeze).
- Pesticides are only applied when ground conditions are suitable. This means avoiding ground that is frozen, waterlogged, snow-covered, actively eroding, or baked dry after drought (and rain is forecast).
- Pesticides are not being applied when drain flows are sufficient to produce surface run-off across buffer areas.
- Pesticide sprayers are not filled directly from a drain, watercourse, pond, or lake.
- Operators are not emptying washings to the same area of ground.
- Waste materials are being disposed of via an approved contractor or facility.

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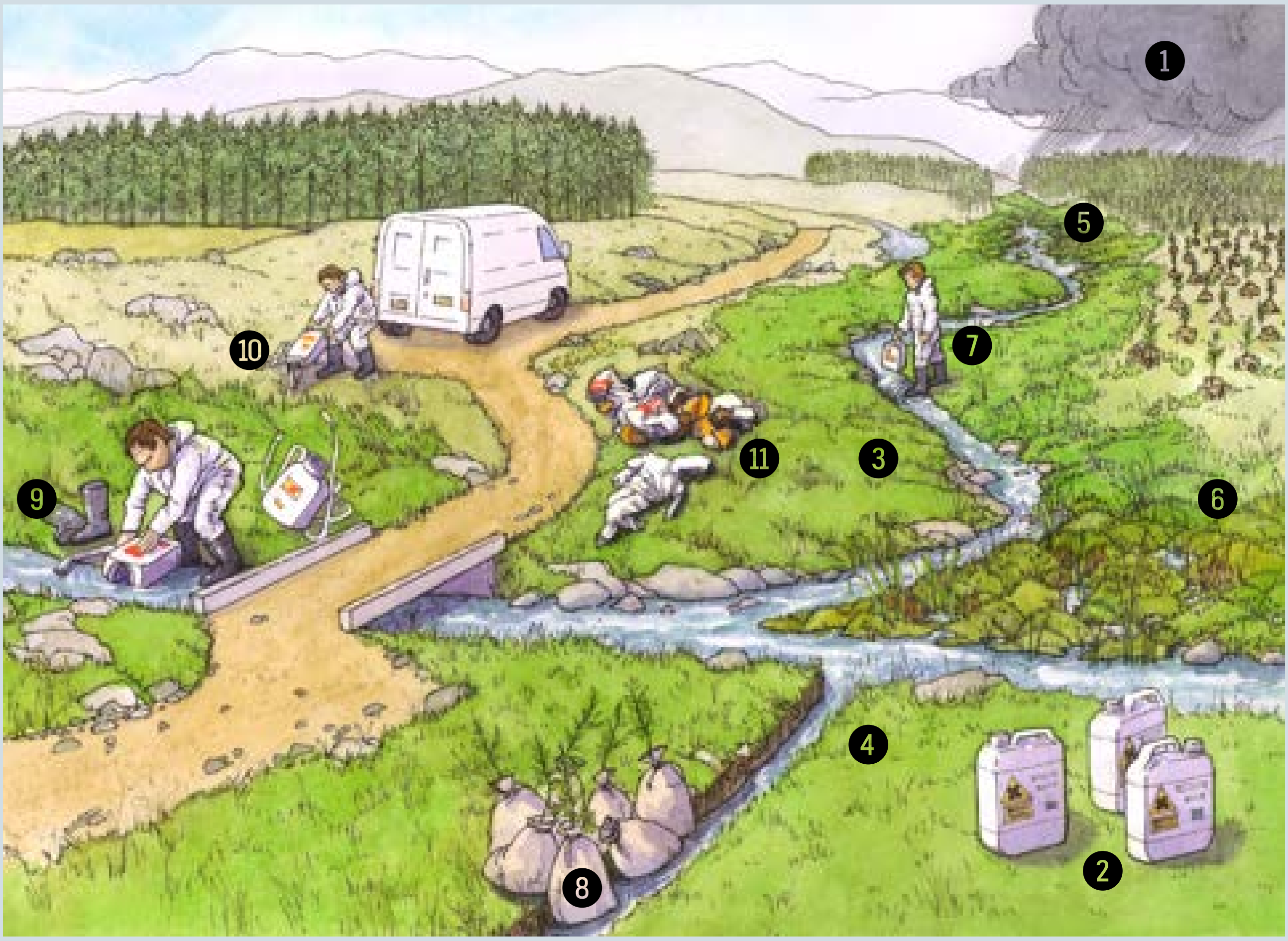
Pesticide users are legally responsible to apply pesticides safely, taking appropriate care to protect human health and the water environment.

Figure 13 Operators need ready access to spill kits and know how to use them.

4. Protecting the water environment from pesticide applications



1. Do not apply pesticides during wet weather (or if heavy rain is forecast within 48 hours), windy conditions (more than a light breeze), or if the ground is frozen, waterlogged, or snow-covered.
2. Read and comply with the instructions on the product label.
3. Do not prepare, store, or apply pesticides or plant treated trees within buffer areas unless the product is approved for use in or near water and you have appropriate authorisation. The possibility of leaving narrower buffer areas along minor watercourses <1 m wide does not apply to pesticide use.
4. Treat drains that have become sizeable and stable watercourses, and those that flow directly into streams (including road drains) as natural watercourses with their own buffer areas.
5. Ensure buffer areas around watercourses are extended to include adjacent boggy/wet ground.
6. Do not apply pesticides when run-off from drains is sufficient to produce visible surface flow across buffer areas.
7. Do not step into or walk along watercourses or drains while wearing contaminated spray suits or footwear.
8. Do not store or soak treated planting stock within a drain or watercourse prior to planting.
9. Do not fill sprayers directly from watercourses or wash sprayers, containers, clothing, or footwear in or near a watercourse.
10. Avoid emptying washings to the same area of ground and do not empty in buffer areas.
11. Do not puncture, bury, burn, or otherwise leave empty pesticide containers, packaging, planting bags, or contaminated spray suits on site.

5. Roads and quarries

Forest road and quarry works and poor or inadequate road maintenance can cause sediment run-off that can degrade water quality through siltation and the creation of excessively turbid water. Fine sediment results from wash-off from road surfaces during vehicle trafficking (Figure 14) and the erosion of steep road drains, embankments and cuttings. Coarser sediments and the mass movement of soil and other debris can result from the failure of side-slopes and the washout of roads due to poorly designed or maintained culverts. Quarries and borrow pits are also a source of run-off which has the potential to be highly polluting to the freshwater environment through siltation, water turbidity, and acidity or metal contamination.

Key planning and operational measures to protect the water environment are set out below. Good practice for operators is illustrated on page 22.

Figure 14 Damaged road surfaces can quickly degrade and cause pollution through sediment run-off.

Planning road or quarry works

An operational plan is required before any road or quarry works, including road maintenance, start on site. This should be informed by the UKFS Guidelines on Forests and Water and the *Road haulage of round timber code of practice*. The aim should be to carefully plan and execute construction and maintenance work to reduce the risk of sediment pollution by minimising and managing run-off. Other important planning considerations will be how best to replace problem culverts and redesign road drains that discharge directly into watercourses. This work should be done before any major road use or harvesting operations start.

Key points for planning are:

- Ensure roads are built outside riparian buffer areas wherever possible.
- Obtain authorisation from the water regulatory authority or lead local flood authority before any engineering works start in or adjacent to watercourses.
- Consult with appropriate authorities when planning watercourse crossings to check the sensitivity of local waters and restrictions on working practices (e.g. no in-stream works when fish are spawning or if there are freshwater pearl mussels within 50 m).
- Map buffer areas around all surface water features, including abstraction points for water supply.

!

Culverts should be of a sufficient size and spacing to cope with volumes of flow for a 1-in-50 year storm (or a 1-in-100 year storm for culvert diameters >1.5 m) and allow for the effects of climate change.

- Ensure that materials used in road construction will not result in metallic, sulphide-rich, or acidic run-off that could pollute nearby watercourses.
- Ensure culverts are of a sufficient size and spacing to cope with volumes of flow.
- Plan for culverts at regular intervals (e.g. every 100 m) to avoid long road drains intercepting and carrying large volumes of water from the ground above (Figure 15).
- Avoid discharging road drains onto unstable slopes or to unstable crops; where this is not possible, reduce water flows by installing additional culverts.
- Restrict road access in terms of vehicle weights and speeds where road specifications fall short of requirements.
- Prioritise the repair or replacement of existing road drains, culverts, and watercourse crossings that require remedial work (e.g. targeting drains connected to watercourses and any blockages to fish), liaising with the local rivers trust (www.theriverstrust.org), fishery body, and/or water regulatory authority as appropriate.
- Prioritise the repair or correction of damaged or eroding culverts; do not wait for these to fail or be washed out.
- Plan to carry out regrading works in dry weather to avoid sediment run-off.

Operational practice

Operational practice should always adhere to the plan. It is essential that road teams and all those working on site are fully aware of the detail of the plan and closely follow any specifications set out there.

Key points for managers of road and quarry works are to ensure that the following measures apply for road and bridge construction, culvert installation, road maintenance, and quarry and borrow pit excavation.

Road construction

- Machine trafficking and other works are minimised within buffer areas.
- Significant road construction works are not carried out where run-off can reach watercourses during periods of wet weather.
- Intercepting trenches or terracing are installed on unstable roadside embankments and cuttings; slopes are kept at no greater than the natural angle of repose to encourage revegetation.

Figure 15 Install regular culverts to manage road drainage.

- Exposed soil is artificially revegetated if natural establishment is slow, especially on highly erodible soils and around culverts and bridges.
- Road surfaces are not dressed with very fine rock material such as quarry dust.

Bridge construction

- Temporary bridges are built as working platforms to reduce bed disturbance and the risk of spillage of chemicals or materials where needed, and especially over sensitive waters.
- Cement and raw concrete are kept out of watercourses during construction works.

Culvert installation

- Hanging culverts are not used in fish-bearing watercourses; the culvert floor should be at the same level and gradient, and carry similar bed material and flow, as the watercourse (Figure 16).
- Culverts are aligned with the watercourse channel to reduce the risk of bank erosion.
- Culverts are well bedded to avoid settlement and displacement, as well as being protected by an adequate cover of road material.
- Substrates and side/head walls are reinforced where necessary.

Road maintenance

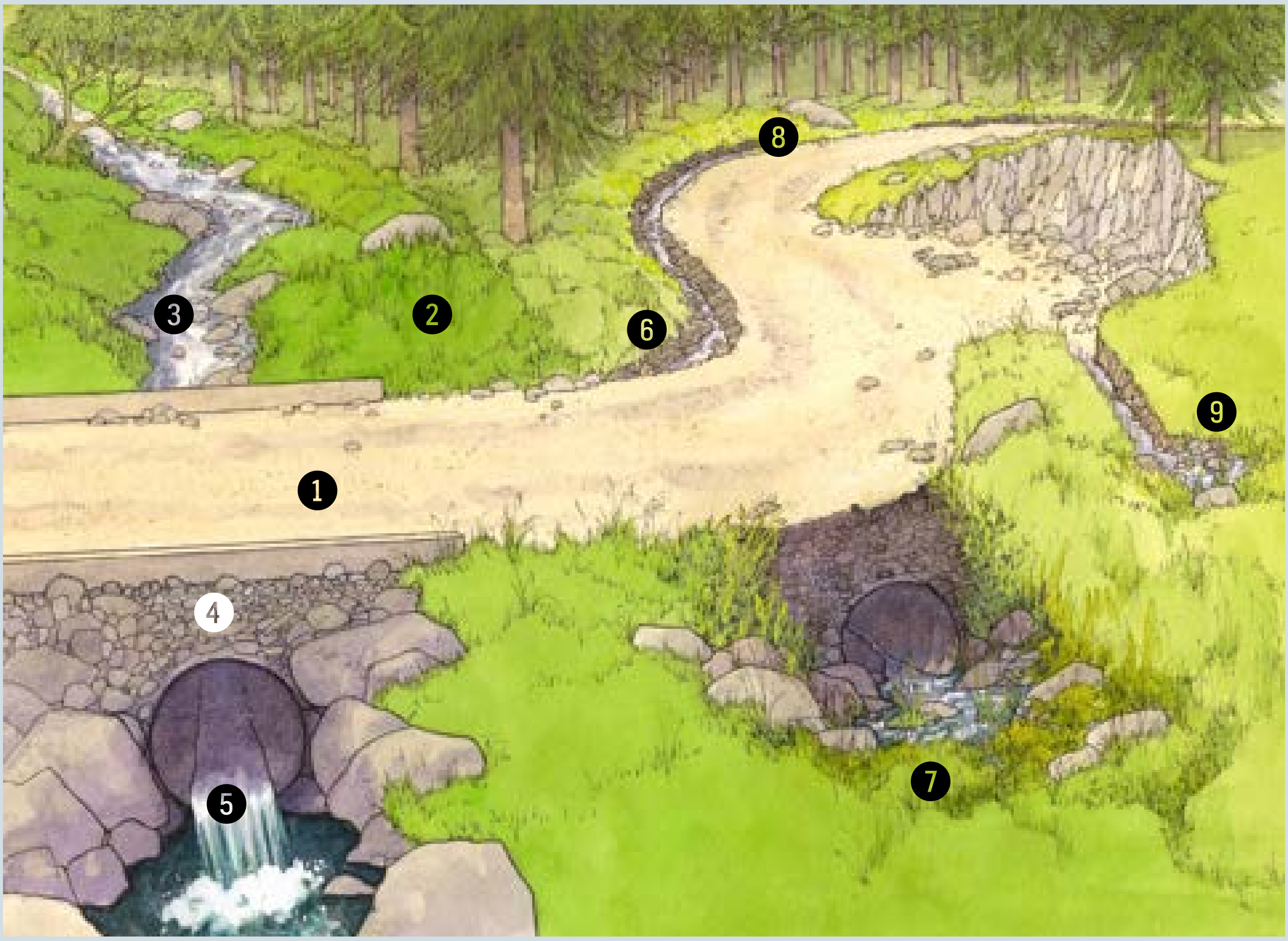
- Road drains and culverts are inspected before and after any intensive use of forest roads, as well as after storm events, and rapid action is taken to remove blockages.
- Adequate road cross-cambers are maintained and any formation of wheel ruts (Figure 17) is quickly remedied – especially where these are flowing with water and actively eroding.
- Drain-side vegetation is not unnecessarily disturbed during drain maintenance.
- Temporary silt traps are installed or an undisturbed section of drain is left when cleaning road drains connected to watercourses (see Section 8).
- Loose spoil is not piled up at road edges that slope down to watercourses.

Quarry and borrow pit excavation

- Seepage waters and surface run-off are discharged to buffer areas of vegetated ground.
- pH of seepage water is monitored – if very acidic (pH <3.0) then water samples should be taken for chemical analysis and advice sought on possible water treatment.

Figure 16 Hanging culverts should be avoided, especially in fish-bearing streams.

Figure 17 Careful planning and execution of construction and maintenance work is key to minimising the threat of sediment pollution.



1. Avoid significant road construction work near watercourses in wet weather.
2. Minimise machine trafficking and working within buffer areas.
3. Any natural watercourse that is intercepted by a road should be culverted or bridged at that point.
4. Culverts should be installed on the same alignment as the watercourse channel.
5. Do not install hanging culverts in fish-bearing watercourses.
6. Install culverts at regular intervals along roads to prevent a build-up of water (e.g. every 100 m).
7. Ensure roadside drains are disconnected from natural watercourses and discharge to a buffer area.
8. Avoid unnecessary disturbance of drain-side vegetation. Leave undisturbed sections or install silt traps when cleaning connected drains.
9. Discharge seepage waters or surface run-off from quarries or borrow pits to a buffer area of vegetated ground.

6. Harvesting

Harvesting is the most disruptive phase of the forest management cycle and it has the potential to cause major water pollution. There are three main threats to water quality: (1) soil damage and disturbance can lead to the run-off of silt to watercourses, causing sedimentation and turbid water (Figure 18); (2) nutrients released from disturbed soil and brash such as phosphate, nitrogen, and dissolved organic carbon can discolour water and cause nutrient enrichment, leading to algal, weed, and microbial growth; and (3) nitrate released from bare ground can enter watercourses and cause water acidification.

Key planning and operational measures to protect the water environment are set out below. Good practice for operators is illustrated on page 30.

Figure 18 Turbid water and downstream siltation can be very damaging to freshwater life and have serious implications for water supplies.

Planning harvesting operations

An operational plan is required before any harvesting operations start on site. The plan should consider both on- and off-site factors and the sensitivity of the wider water catchment. It should be informed by the UKFS Guidelines on Forests and Water and Forests and Soil. The aim should be to minimise ground disturbance and to manage nutrient losses by controlling the scale of harvesting operations in a catchment. The plan should extend to the catchment level and consider the potential impact on downstream water users (e.g. if water from the catchment drains to a drinking water supply or fish farm), or where protected or priority species and habitats are present and could be adversely affected.

Key points for planning are:

- Check with the local water company whether the site drains to a public water supply and with the local authority environmental health department, land occupiers, and neighbours if it serves as a private water supply.
- Check with the statutory nature conservation agency for the presence of protected or priority species and habitats, including within downstream shallow coastal waters.
- Check if there are any local fish farms.
- If the site drains to a public water supply, fish farm, or waters supporting priority freshwater

species or habitats, identify the catchment boundary (using the method described in the Forestry Commission Practice Guide *Managing forests in acid sensitive water catchments*). Calculate the area of the catchment (including the lake surface) and the extent of any recent and proposed forest felling, including that by other forest owners. Ensure the plan limits any felling to less than 20% of the catchment in any three-year period.
- If the site drains to a private water supply, identify the catchment boundary and minimise machine trafficking and brash heaps within it. For spring supplies, assume that the boundary follows the surface water divide unless local information implies otherwise.
- Select the most appropriate harvesting system and machine combination for site conditions (including methods of felling, timber processing, and extraction) to minimise the risk of ground damage and sediment run-off (Tables 2a and b).
- Plan to minimise the number of stream and drain-crossings but avoid situations where alternatives create more difficult and potentially damaging extraction routes.
- Use soil maps and detailed topographic data to characterise the site in terms of the risk of ground damage, erosion, and sediment run-off to watercourses.
- Identify appropriate buffer areas (Table 1) to protect all watercourses, wet flushes, boggy ground, and water supply infrastructure where present.
- Plan extraction routes to avoid buffer areas and valley bottoms (Figures 19 and 20, respectively).
- Where access from the forest road is difficult, select a harvesting method that minimises road usage by extraction machinery.

> **!**
> Always focus on ground protection and do not select a less suitable harvesting system or machinery in the hope that any sediment run-off can be managed by using silt traps or geotextile barriers.

Figure 19 Locate extraction routes outside riparian buffer areas, which are very vulnerable to ground disturbance.

Figure 20 Avoid long extraction routes along valley bottoms and provide sufficient protection using brash and, where necessary, logs.

- Consider the use of long-reach harvesters and processors where there is likely to be a shortage of brash for soil protection.
- Consider felling but not extracting trees where extraction is likely to cause unacceptable ground damage. Alternatively, use materials such as oak mats, geotextiles, or aluminium or plastic sections to protect extraction routes, which can be lifted and reused after operations.
- Avoid felling conifer crops on one side of a watercourse that would leave others exposed on the opposite bank, where these are very vulnerable to windblow (Figure 21).
- Assess the risks of harvesting causing slope failure and debris flows on steep/unstable ground and amend plans accordingly (Figure 22).
- Consider the need for appropriately constructed semi-permanent access routes to minimise future ground damage.
- Locate processing and timber stacking sites outside of buffer areas and ensure run-off does not drain directly into watercourses.
- Plan to monitor weather forecasts daily and review work plans accordingly.

Table 2a Terrain classification for forest operations: select the terrain class number for ground condition, ground roughness, and slope*.

Ground description	Terrain class				
	1	2	3	4	5
Ground conditions	**Very good** (e.g. dry sands and gravels)	**Good** (e.g. firm mineral soils)	**Average** (e.g. soft mineral or iron pan soils in drier areas)	**Poor** (e.g. peaty gleys in drier areas and soft mineral soils in wetter areas)	**Very poor** (e.g. peaty gleys in wetter areas and deep peats)
Ground roughness	**Very even** (e.g. obstacles such as boulders or plough furrows are small or widely spaced)	**Slightly uneven** (e.g. obstacles are intermediate between Very even and Uneven size and spacing)	**Uneven** (e.g. obstacles of ~40 cm at 1.5-5 m spacing)	**Rough** (e.g. obstacles are intermediate between Rough and Very rough size and spacing)	**Very rough** (e.g. obstacles of ~60 cm or more in height at 1.5-5 m spacing)
Slope of ground	**Level** (0–10% or 0–6°)	**Gentle** (10–20% or 6–11°)	**Moderate** (20–33% or 11–18°)	**Steep** (33–50% or 18–27°)	**Very steep** (>50% or >27°)

*Sites are described by terrain class numbers and are always in the standard order of '**condition : roughness : slope**'. For example, a 4 : 3 : 2 site means a site with Poor, Uneven ground conditions and a Gentle slope.

Table 2b Approximate terrain limits* of extraction machinery based on terrain class taken from Table 2a above.

Machine type	Ground conditions	Ground roughness	Slope	Remarks
2WD Agricultural tractor: • uphill extraction • downhill extraction	 3 4	 3 3	 2 3	Uphill extraction may require a reduced load.
4WD Agricultural tractor: • uphill extraction • downhill extraction	 3 4	 4 4	 3 4	Uphill extraction may require a reduced load.
Forwarders, frame-steered: • uphill extraction • downhill extraction	 3 4	 4 4	 3 4	Uphill extraction may require a reduced load. Bandtracks are essential in the worst conditions.
Skidders, frame-steered: • uphill extraction • downhill extraction	 3 4	 4 4	 3 4	Uphill extraction may require a reduced load. Bandtracks are essential in the worst conditions.
Cable way	5	5	5	–

*Terrain limits are maximum values based on reasonable weather conditions and experienced operators. It is important to err on the cautious side when the operator is less experienced or in the event of adverse weather. The main exceptions to this are in poor and very poor conditions, where the use of control measures such as eight-wheeled machines, large flotation tyres, bandtracks, smaller timber loads, and thick brash mats can reduce ground pressures and the risk of bogging and soil/site damage.

Figure 21 Windblow of bankside trees can be very damaging to watercourses and cause much erosion and siltation.

Figure 22 Seek hydrological advice on how to manage eroding gulleys, including how to remedy overloaded watercourses.

Operational practice

Operational practice should always adhere to the plan. It is essential that harvesting teams and all those working on site are fully aware of the detail of the plan and closely follow any specifications set out there. Site conditions, including the condition of buffer areas, watercourses, and culverts should be checked after operations are completed and action taken to correct any problems.

Key points for managers of harvesting operations are to ensure that the following measures apply for felling and thinning trees, processing and extracting timber, crossing watercourses, and stacking and loading timber.

Felling and thinning

Riparian areas are very susceptible to ground damage by harvesting operations and must be protected from disturbance.

Felling and thinning trees, either manually or by harvester, generally poses a lower risk of ground damage than extracting the timber. Riparian buffer areas are the exception. You should ensure:

- Trees are felled away from watercourses to avoid disturbing banksides and stream channels.
- Upturned root plates are replaced to restore banksides where accessible and conditions allow.
- Trafficking by harvesting machinery is avoided within buffer areas.

Timber processing

Fresh brash is a major source of soluble nutrients that can leach to water, contributing to nutrient enrichment.

The main risk to the freshwater environment from processing felled timber results from the management and placement of brash. You should ensure:

- Brash is not concentrated in large heaps within buffer areas (Figure 23).
- Run-off from brash rows, brashed extraction routes, and brash heaps is managed so that it does not flow directly into watercourses.
- Log steps, pipe culverts, or shallow drains are used to split and divert surface run-off to undisturbed, preferably brash-free, vegetated ground (Figure 24).
- Rides are retained as cross-slope, brash-free, vegetated buffers that are not used for extraction.

Figure 23 Nutrient run-off from fresh brash can lead to low oxygen levels and the growth of sewage fungus in drains.

Figure 24 Nutrient- and carbon-rich leachate from brash heaps can pollute local watercourses; divert any run-off to vegetated ground.

Timber extraction

The extraction of felled timber to roadside presents the greatest risk of water pollution so particular care is required in the siting, design, and construction of machine access routes and roadside timber stacking and loading areas. The run-off of sediment poses the main threat so the most important consideration is to avoid significant ground damage. You should ensure:

- Extraction machines are kept within the forest where possible; forest roads are only used for initial access and refuelling – particularly if the machines have wheel chains or band tracks.
- No watercourses, including temporarily dry channels, are being used as routes for extraction.
- Operations are suspended during heavy rainfall but long breaks in working are avoided.

> **!** Where ground damage occurs and generates turbid water, measures must be taken to disrupt site run-off to filter and retain sediments before they reach watercourses.

Cable-ways and tethered harvesting

- Worn trails are not formed by the repeated dragging of tree tops along the same route.
- Ruts are not formed by the operation of tethered machines on steep or very steep slopes.

Forwarders

- Dog-legs are used to avoid long, straight extraction routes to help deflect run-off on steeper slopes – especially in areas of high rainfall.
- Extraction tracks are designed with a crossfall on transverse slopes. This should slope into the hillside at about 1:20, with a depression at the cut face to act as a cut-off drain to channel run-off away from the track surface (unless soil is well drained).
- Low spots are built into gentle slopes, or offlets installed every 30 m along extraction tracks to allow run-off to be diverted onto the downslope hillside.
- Adequate brash mats are maintained on key extraction routes (Figure 25) and action is taken as soon as significant ruts start to form, such as importing fresh brash or low quality produce to protect the soil, or installing log steps to deflect run-off to adjacent undisturbed ground (Figure 26).
- Machine load weights and the number of machine passes is restricted to protect soils if machine choice is limited and less suited to site conditions.
- Extended breaks in working soft ground sites are avoided, unless fresh brash can be imported for thatching or reworking is restricted to drier periods.

Figure 25 A good brash mat protecting the soil from disturbance and minimising the run-off of sediment.

Figure 26 Logs plus brash may need to be used to protect very soft ground from harvesting damage.

Skidders

- Skidders are not used for extraction on soft ground.
- Extraction routes are protected with brash to avoid the formation of deep ruts and worn trails.
- Logs and whole trees are not winched through watercourses.

Watercourse crossings

Watercourse crossings are extremely vulnerable to disturbance, causing direct damage to banksides and channels, which can introduce significant quantities of sediment. It is essential that all crossings are protected from damage, even very small channels (Figure 27). You should ensure:

- Crossings are designed to protect the water channel and water flows from disturbance, taking advantage of natural features such as rock outcrops and narrow sections of channel (Table 3).
- Where there are no suitable natural features, artificial structures are used to protect crossings.
- There is sufficient capacity for the selected structure to cope with predicted water flows and the risks posed by washout have been considered (Figure 28).
- Clearance for water flows under/through watercourse crossings are regularly checked and maintained during the period of use, especially when heavy rainfall is forecast. Broken or damaged pipes should be replaced.
- Approaches to crossings are protected with brash or stone ramps to avoid muddy water flowing down ruts or being forced out of depressions during machine passes.
- Structures are strong enough to support machinery and timber loads and overlaid with brash to distribute wheel loads, retain mud and avoid machine slippage.
- Crossing points are not located above water intakes for public or private water supplies, fish-spawning gravels, or freshwater pearl mussel populations (leave a minimum 50 m buffer).

Table 3 Structures and materials for protecting temporary watercourse crossings.

Size of watercourse	Structures and materials
Small (<1 m)	• Timber bundles: groups of logs that are placed longitudinally within ditches to facilitate crossing. They can only be used at low flow and must be removed immediately after use. • Timber bundle with Armco pipe: as above but the logs are placed on top of a section of Armco pipe. The latter permits normal water flows and therefore allows usage in small, incised streams. • Polypropylene pipes: single- or double-walled pipes with supporting logs and brash for preserving minor run-off channels. • Steel pipes: solid steel pipes with log surrounds for protecting small streams.
Medium (1–3 m)	• Corduroy rafts: lengths of timber placed side by side which can also be linked together by cables. They provide temporary reinforcement of approaches to streams that often have a low bearing capacity and thus are easily damaged by machinery. • Sleeper bridge: timber bridge made out of Jarrah crossing sleepers for crossing medium-sized streams (1–1.5 m width) with good approaches and sound bankside foundations.
Large (>3 m)	• Fascines: purpose-built bundles of high density polypropylene pipes (single- or double-walled) secured together by steel chains. Suitable for crossing larger streams. On deep peat, careful preparation and bedding down on a brash base may be necessary to avoid premature sinkage and difficult retrieval. • Log bridges: sets of logs bound together in a cross design to form a bridge platform, capable of spanning larger streams up to 4 m in width (they can also be used to cross medium-sized watercourses). • Temporary steel bridge: prefabricated steel bridge unit for spanning larger streams. Requires track access for crane and lorry, and sound abutments made of timber sleepers or rock gabions, depending on usage.

Figure 27 At this site, failure to respect watercourses has resulted in significant soil disturbance and siltation.

Figure 28 In this situation pipes need to be installed along with logs to prevent water backing up and causing site waterlogging and ground damage.

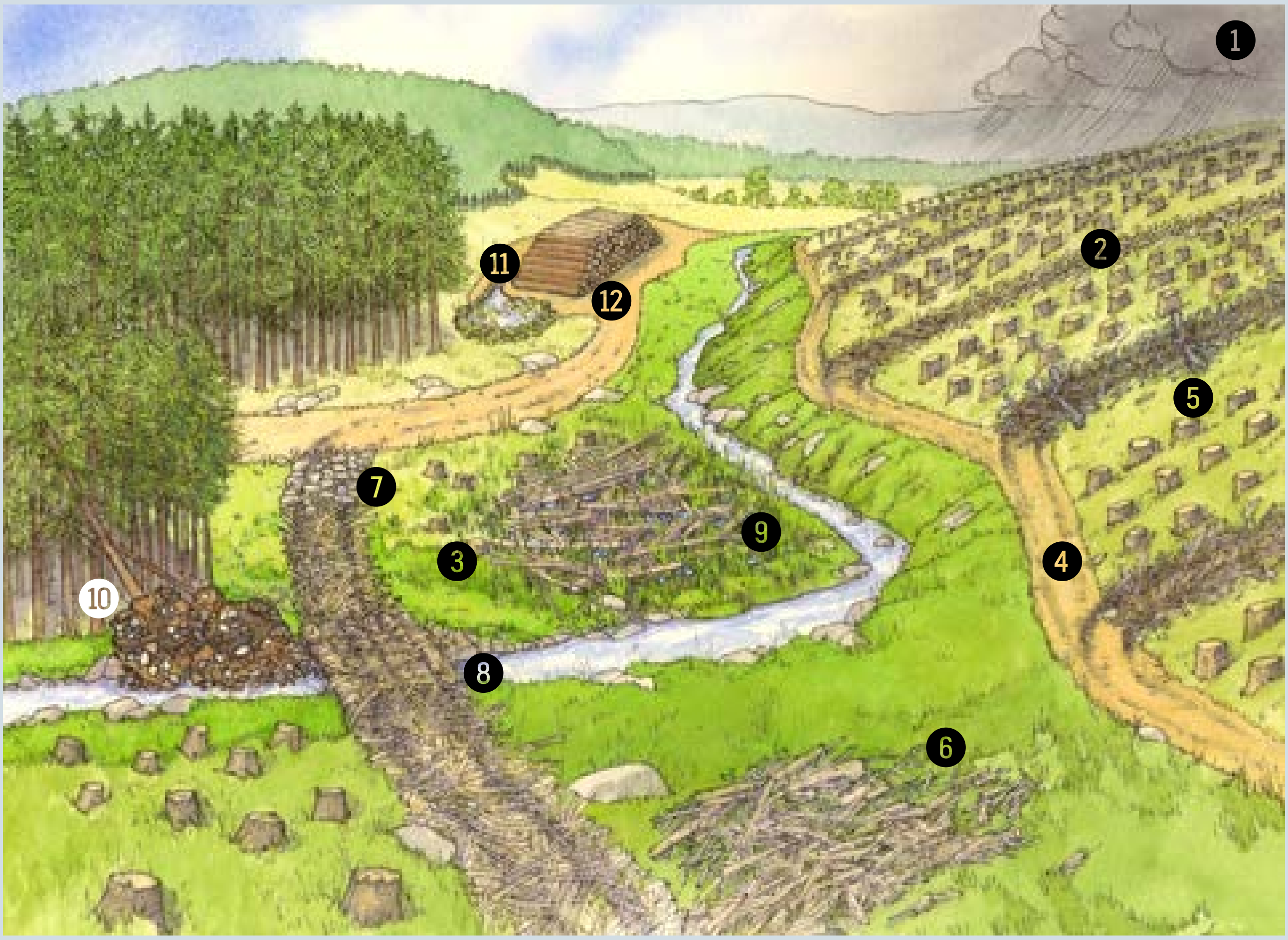
- Temporary structures are removed after harvesting operations are completed, and care is taken to avoid the release of sediment into waters (see Section 8).
- Fording of streams and rivers is avoided, unless there is an existing purpose-built ford, and measures are taken to avoid the risk of water pollution (including protecting approaches from ground disturbance and rutting). Advice should be sought from the water regulatory authority.

Timber stacking and loading

Machine access points and roadside timber stacking and loading areas are particularly vulnerable to ground damage. Care is required in siting, design and construction to reduce the risk of sediment-laden run-off and water pollution. You should ensure:

- Operations to offload timber use well-thatched forwarder routes that run parallel to the forest road, rather than from the road itself.
- Ramped access points are constructed with compacted fill and a pipe drain on all but shallow angle slopes. Log ramps are avoided.
- Ramps are set at an angle to the road in the direction of required travel.
- A surface layer of clean stone (e.g. a 300 mm deep layer of 100–200 mm sized stones) is considered for ramps with muddy approaches, especially where road drains are directly connected to watercourses.
- Log steps are installed on forwarder route approaches to roads to divert muddy waters away from road drains and onto adjacent undisturbed ground or to a brash bund.
- Run-off onto stacking and loading areas from adjacent land and road surfaces is reduced by maintaining road camber and road drains.
- Run-off from timber stacking and loading areas is diverted to undisturbed and preferably vegetated ground, or where necessary, to a brash bund or other silt trap (Section 8).
- Stacked timber is not blocking road drains and sufficient space is left for lorries to stand on the main road structure away from the drain edge (normally aided by stacking timber on the outside road edge).
- Timber bearers are used where logs have to be stacked parallel to the road drain and timber is not stacked on both sides of the forest road.
- Layers of mud are scraped away from affected areas to avoid damage to the road pavement (material should be dumped well away from buffer areas).

6. Protecting the water environment from harvesting operations



1. Monitor weather forecasts daily and amend work plans accordingly. Suspend operations during heavy rainfall but try to avoid long breaks in working.

2. Avoid long, straight extraction routes and ensure brash mats are maintained.

3. Avoid using skidders on soft ground.

4. Keep extraction routes outside buffer areas and valley bottoms wherever possible.

5. Use log steps where rutting occurs to split run-off and divert it to unbroken ground.

6. Locate brash heaps outside buffer areas and ensure run-off does not drain directly into watercourses.

7. Use stone ramps to protect main access routes.

8. Protect stream crossings from damage to stream banks and bed.

9. Consider felling crops but not extracting timber where this would cause major damage to very soft ground.

10. Avoid exposing conifer crops on the bank of a watercourse opposite the felling site, where these are vulnerable to windblow. Where practical, try to replace any upturned root plates to restore banksides.

11. Ensure run-off from roadside timber stacks and loading areas does not drain directly into watercourses; disconnect road drains.

12. Suspend operations if heavy rainfall leads to a build-up of mud on timber stacking and loading areas, especially where there is a risk of run-off reaching local watercourses.

7. Vehicle and machine maintenance

The use of fuel oils and lubricants for vehicles and forestry machinery can pose a risk to the water environment if not properly handled (Figure 29). A leak or spillage of any type of oil, including bio-oil, can cause widespread pollution of the water environment and harm freshwater ecology. It can also contaminate drinking water supplies and disrupt water treatment, causing serious problems for water users. There are legal requirements (Oil storage regulations) with respect to the storage of oils and fuels in the forest aimed at preventing water pollution. Particular care is required in their storage, transport and handling in the forest environment.

Key planning and operational measures to protect the water environment are set out below. Good practice for operators is illustrated on page 34.

Figure 29 Oil can form a surface film over water that can extend a considerable distance downstream.

Planning maintenance operations

Maintenance operations should be carefully planned. The plan should be informed by the UKFS Guidelines on Forests and Water. The aim should be to minimise the risk of fuel or oil spillages and water contamination. A contingency plan that sets out the emergency action that must be taken in the event of an accidental spillage should be drawn up (see Section 8).

Key points for planning are to:

- Check for the presence of public and private water supplies before any machines go on site. Ensure that a 50 m buffer is put in place around all surface waters, springs, wells and boreholes if it is necessary to store and handle fuel oils and lubricants, or refuel vehicles and machines on land draining to any water supply.
- Identify safe locations for machine servicing and the storage and handling of fuel oils and lubricants to minimise the risk of leaks or spills causing water pollution. Where possible, limit machine servicing involving changing oils and filters to workshops.
- Ensure all staff involved in site operations are informed about the threats posed to the water environment from fuel oils and lubricants.
- Ensure personnel are trained in the correct use of diesel-handling systems and make them aware of pollution risks and how to handle spills.
- Arrange for cans and drums to be removed on a daily basis, especially in vandal-prone areas.

> **!** As far as practicable, do not plan to store or handle fuel oils and lubricants, or carry out refuelling of vehicles and forest machines within water supply catchments.

Operational practice for maintenance

Operational practice should always adhere to the plan. It is essential that all those working on site are fully aware of the detail of the plan and closely follow any specifications set out there.

Key points for managers are to ensure that the following measures apply during maintenance operations for the storage, handling, transportation, and disposal of fuel oils and lubricants.

Storage

!

Bunded tanks should be capable of storing 110% of the capacity of the largest tank or container and 25% of the volume stored in multiple containers.

- Storage bunds, containers, equipment, and machinery are kept in a good condition and checked regularly for leaks. Minor leaks such as slowly dripping tanks or hoses, which can easily go unnoticed, can lead to a large spill over time (Figure 30).
- Double-skinned or bunded, securely lockable tanks are used where there is a need to temporarily store fuel oil or lubricants on site.
- Bunds are covered to reduce the build-up of contaminated rainwater.
- Damaged, badly corroded or leaking vessels, particularly cans and drums, are removed for disposal at a suitable licensed site.
- Bowsers are not overfilled and are protected by secure, leak-proof lids and fittings, vented with one-way valves.
- Stabilising legs are used on bowsers to prevent tipping when less than half full.

Handling

- Containers of fuel oils and lubricants are kept on flat ground and away from the immediate working area of machinery and the edge of embankments (Figure 31).
- Buffer areas are not used for the storage and handling of oils and lubricants, or the refuelling, washing, and repairing of machinery. The possibility of leaving narrower buffer areas along minor watercourses <1 m wide does not apply to these activities.
- Transfer hoses are used to refuel tanks and locked when unattended.
- Fuel tanks are not suspended using a hydraulic loader or placed on high points such as timber stacks or embankments to aid refuelling by gravity.
- Funnels are used whenever fuel or lubricants are being poured from cans or drums.
- External drum-top mats or basal pans are used to absorb minor spillages.
- Avoid rolling large drums on wooden trestles to assist filling.

Figure 30 Small leaks and spills can accumulate over time and cause pollution.

Figure 31 Containers placed on uneven ground are more liable to tip over, resulting in serious spillage.

Transport

- Vehicles, machinery, bowsers, or un-bunded tanks are not parked or left on bridges, or near to watercourses or drains – especially for extended periods.
- Bowsers are fit for purpose and weight restrictions are observed.
- Containers are secured during transport and loads are properly distributed.
- Appropriate vehicles are used for transporting oil drums.

Disposal

- Oil-soaked brash, soil, and any used absorbent materials are dry-bagged within drums and removed for safe onward disposal.
- Empty fuel and lubricant containers are not punctured, burned, buried, or left on site.
- All waste oil is returned to workshops for disposal.

Cleaning

- Vehicles, forest machines, and equipment are regularly cleaned to avoid the build-up of oil-soaked soil and other debris.
- The cleaning of vehicles, forest machines, and equipment is not carried out within buffer areas or on watercourse crossings (Box 5).

Box 5 Biosecurity measures for vehicles and forest machinery

Biosecurity is a set of precautions that aim to prevent the introduction or spread of pest species. These species include invasive animals and plants (which may be native or non-native) and other harmful organisms such as tree diseases.

Invasive non-native animals such as the American signal crayfish and killer shrimp, and plants such as floating pennywort, giant hogweed, Japanese knotweed, and Himalayan balsam, can cause serious damage to watercourses over large areas. Removal is difficult and expensive.

The eggs and juveniles of invertebrates, and seeds and root fragments of plants, can be trapped in mud and debris attached to vehicles and forest machinery. If not properly cleaned these can be transported to other sites where they may fall off and spread to new watercourses.

Biosecurity best practice

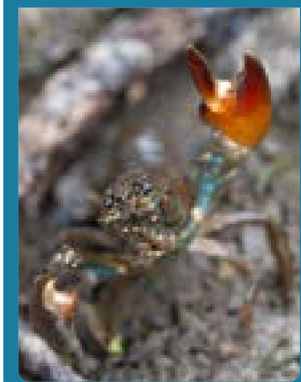
You can help stop the spread of invasive species by thoroughly cleaning vehicles and forest machinery before and after moving between sites. Cleaning areas should be located in well-vegetated areas so contaminated water run-off is captured for settlement and natural soakaway. Don't clean vehicles and forest machines near drains or on waterlogged ground.

- ✔ Arrive with clean vehicles, machines and equipment and disinfected footwear.
- ✔ Use clearly marked cleaning stations on site.
- ✔ Ensure vehicles and forest machinery are clean before leaving the site – this includes tyres, wheel arches, and undersides.
- ✘ Do not clean machinery, equipment, or footwear in or near watercourses or drains.

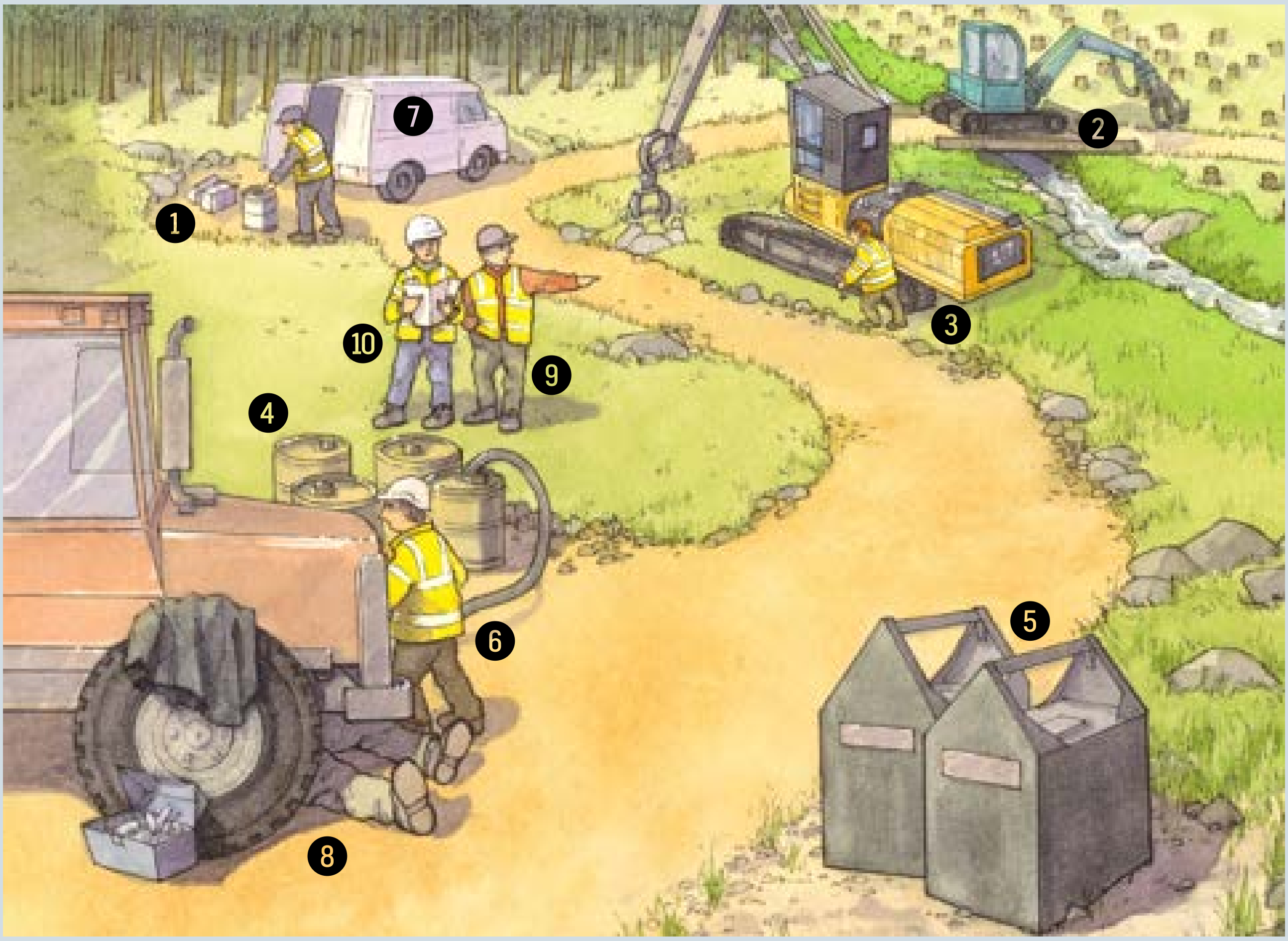
Further information and advice is available from the Non-native Species Secretariat (**nonnativespecies.org**) or contact the relevant local environmental or water authority.

!

American signal crayfish are voracious predators, feeding on a variety of fish, frogs and invertebrates as well as plants. They have decimated native crayfish populations where present. The crayfish also cause problems by burrowing into riverbanks causing erosion, bank collapse, and sediment pollution.



7. Protecting the water environment from vehicle and machine maintenance



1. Remove waste or recovered oil from the site in an impermeable container and dispose of at a suitable licensed site; do not puncture, bury, burn, or leave empty containers on site.
2. Do not park vehicles, machinery, or bowsers or locate un-bunded tanks on bridges or near to watercourses or drains.
3. Do not store or handle oils and lubricants, or refuel, wash or repair machinery, within buffer areas. The possibility of leaving narrower buffer areas along minor watercourses <1 m wide does not apply to these activities.
4. Keep containers of fuel oils or lubricants on flat ground and away from the immediate working area of machinery.
5. Use double-skinned or bunded, securely lockable tanks where there is a need to temporarily store fuel oils or lubricants on site; provide a cover to reduce the build-up of contaminated rainwater.
6. Always use a transfer hose when refuelling.
7. Use appropriate bowsers or drums for fuel transport and do not overfill; secure drums within vans, ensuring proper weight distribution.
8. Regularly check to ensure there is no leak of fuel or lubricants from machinery and equipment.
9. Consider potential threats posed to water from the handling of fuel oils and lubricants.
10. Review the contingency plan and ensure you know how to correctly use diesel-handling systems and what to do in the event of a spillage.

8. Contingencies

Planning and good practice will ensure that forest operations are carried out in a way that minimises risks to the water environment. However it is important to have procedures in place to mitigate potentially harmful impacts should unforeseen events occur.

Contingency plans set out the detail of what happens in the event of accidents or unexpected or unplanned events. The water environment is particularly vulnerable to events such as sediment pollution, or contamination from oil or chemical spillages that could arise during forest operations. A contingency plan will help ensure that if such an event occurs the effects on the water environment will be contained and mitigated.

Key planning and operational measures to protect the water environment are set out below. Good practice for operators is described in the subsections on dealing with sediment release, oil or chemical spillages and the use of fire-fighting chemicals.

! The Environmental Liability Directive (2004/35/EC) seeks to prevent and remedy environmental damage and reinforces the 'polluter pays' principle, making operators financially liable for damage.

Contingency planning

An appropriate contingency plan should be in place before any work starts on site. The plan should be informed by the UKFS Guidelines on General forestry practice and consider both on-site and off-site factors and the wider water catchment. The aim should be to set out the detail of what should happen in the event of an unexpected or unplanned event that could pose a risk to water supplies or aquatic ecosystems.

Key points for contingency planning are to:

- Set out clear lines of communication that describe the roles and responsibilities of all relevant personnel, including site managers, contractors, and machine operators.
- Make available the telephone numbers of key contacts (e.g. water regulatory authority, downstream landowners, water users, local water company, and accredited spill contractor).
- Produce a map showing the location of particularly sensitive areas of water, such as abstraction points for water supplies and the presence of vulnerable protected and priority species.
- Set out the emergency procedures and actions to be taken in the event of an incident on site.
- Ensure that staff have adequate training in dealing with contingencies and access to all of the necessary equipment to deal with them.
- Ensure stocks of materials and equipment used to tackle sediment release or spillages are packed, ready, and available for use from the local office, site store, and/or in a strategically placed caravan or trailer. Stocks should include geotextile fabric, personal protective equipment, booms, absorbent sheets/pillows, sandbags, straw bales, heavy duty bags, and an assortment of wooden boards, timber stakes, plastic sheeting, PVC piping, rope, and tools.
- Ensure cabs are equipped with spill kits to temporarily contain and absorb spillages. Kits should contain protective gloves, an absorbent material (such as sawdust), a brush and shovel, and a plastic bag to collect any contaminated absorbent material.
- Consider issuing a pollution/spillage control card to operational staff to improve the response to spillage incidents (see Appendix 1).
- Ensure that plans are regularly reviewed and updated to check compliance, pollution control equipment maintenance, and supplies.
- Ensure there is a system for recording and reporting pollution incidents.

Operational practice for sediment pollution

In most cases, matching cultivation, drainage, and harvesting operations to site conditions, together with appropriate buffer areas, should be sufficient to prevent soil erosion and sediment pollution. If erosion does occur, the amount of sediment entering watercourses can be reduced by the use of silt traps and geotextile barriers. However, these should be seen as an emergency measure and not a substitute for good site planning and practice. Their preplanned use should be limited to controlling the impact of specific engineering operations, such as road construction or maintenance, where major soil disturbance is unavoidable.

Silt traps are excavations or bunded features that are designed to slow the flow of run-off by creating a pool to promote the settlement and retention of sediment. They can vary in size and complexity, from individual small brash dams to large sedimentation ponds. Geotextile barriers are installed across the flow of water to hold back or filter run-off and comprise a variety of fabrics or membranes with differing permeability.

Key considerations when using silt traps or geotextile barriers to tackle a sediment problem are set out below and illustrated on page 38.

Key points for managers tackling a sediment problem are to ensure that:

- Operations are suspended as soon as sediment-laden water arises.
- The source of the sediment is traced and extent of soil disturbance quickly identified.
- Downstream water users are notified and, if necessary, advice sought from the local water regulatory authority on managing the pollution incident.
- Remedial action is taken as close as possible to the source of the sediment. If this is using silt traps or geotextile barriers, they are positioned before water enters drains or stream channels. Good practice for the use of silt traps, bunds, and geotextile barriers is set out in Box 6.
- Sediment-free run-off is diverted around or away from the sediment source.
- Sediment-laden run-off is temporarily diverted to a side channel, through sediment traps and then back into the main channel, or led to separate silt traps, brash bunds, built soil berms, or excavated, blind, cut-off ditches (Figure 32).
- The diversion of flows or installation of silt traps within natural watercourses are only done as short-term emergency measures to allow remedial works. Retaining these for any significant length of time (more than a few days) is likely to require consent from the local water regulatory authority or lead local flood authority.

Coarse sediment moves along the bed of a channel and will readily deposit in a matter of seconds when flow conditions allow. Finer sediment is carried in suspension and may take hours or days to settle out. Very fine sediment such as clays can remain suspended for several weeks. It is fine sediments that contribute to water turbidity.

Figure 32 A brash bund can provide an effective filter for retaining sediment, providing run-off volumes do not exceed the capacity of the system.

Box 6 Using silt traps, bunds and geotextile barriers

The performance of silt traps, bunds, and geotextile barriers in removing and retaining sediment depends on a number of factors. These include the volume and speed of water flow, and the size and amount of sediment. To be effective, barriers need to be designed to local site conditions, and regularly maintained. A series of small silt traps may work better than one large trap.

Designing and installing silt traps and bunds

- Design silt traps to cope with the volume and speed of flow so that the water will be retained for a sufficient length of time to allow the settling out of sediment (Figure 33a).
- Design the inflow to avoid creating turbulent water and erosion (Figure 33b).
- Consider using coir mats or stone aggregate to help trap sediment (Figures 33c,d).
- Dig straw bales into the side walls of drains to improve sediment trapping.
- Use brash and heather bales when constructing bunds. These are better at filtering sediment than solid barriers such as PVC sheeting or straw bales, which can easily result in overspill.
- Pin bales into place during wet weather and periods of high flow to prevent movement and the risk of the bund failing.
- Use a horseshoe-shaped design to reduce the risk of water flowing around side walls; coir roles can be used for this purpose.

Designing and installing geotextile barriers

- Do not use geotextile barriers across watercourses since they will struggle to cope with anything other than very low flows (Figure 33e).
- Select barrier materials with an appropriate level of permeability to best deal with the size of sediment and rates of water flow; take the likely level of maintenance into account.
- Dig the base of the barrier into the soil using an excavated trench (10–15 cm deep) to prevent bypass flow underneath.
- Where possible, use a continuous roll of geotextile barrier to avoid joints, which can easily leak and be forced open, especially at higher flows.
- Support barriers with regular timber posts of minimum 75 mm diameter; these should be driven into the soil at a slight upslope angle for greater stability (Figure 33f).

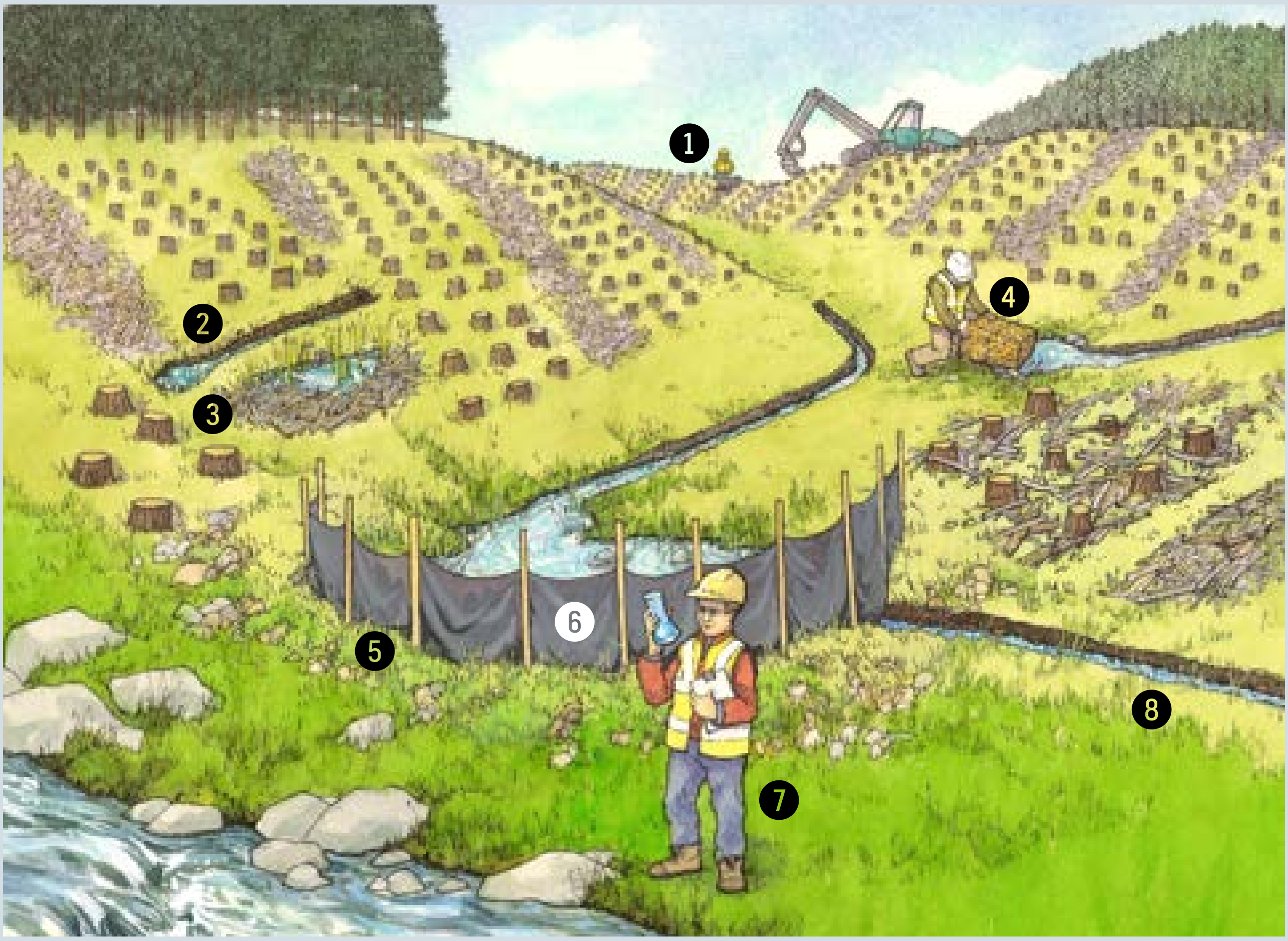
Safety and maintenance

The use of silt traps and geotextile barriers, especially as larger structures, can present a number of health and safety risks, including, in extreme cases, drowning.

- Assess the risks to forest users, and the likelihood of the structures being interfered with, before installing silt traps and geotextile barriers.
- Assess the risk to the water environment from the construction, side wall failure, or washout of large silt traps and only use where acceptable.
- Install fencing and signage as appropriate, warning of potential dangers, for example, 'Caution – deep water'.
- Check the condition of silt traps and barriers regularly, and especially after storm events, and repair as necessary.
- Once the sediment incident is over, leave smaller silt traps and bunds in place to gradually fill and revegetate over time, unless their size poses a health and/or safety issue.
- Temporarily divert the water flow or install a downstream silt trap when removing barriers or cleaning out silt traps within watercourses; undertake the work during periods of low flow.
- Do not dump excavated sediment/spoil within buffer areas.
- Visually check the quality of the outflowing water from silt traps or geotextile barriers regularly to ensure that the design is effective, and adjust as necessary.

! Where possible, always try to reduce the volume of water coming into contact with the sediment source. It is much easier to retain and filter smaller volumes of turbid water.

8. Protecting the water environment from sediment pollution



1. Suspend operations if a sediment problem is identified; walk the site to identify the source and the extent of the problem.
2. Install a cut-off ditch to reduce the flow of surface water draining to sediment sources where needed.
3. Locate barriers or traps as close to sediment sources as possible; use brash bunds to reduce the amount of sediment run-off from the land.
4. Use smaller silt traps formed from straw bales or other materials to try to retain sediment within drains; secure these traps in place to prevent movement or washout.
5. Use geotextile barriers for larger sediment problems; ensure these are well dug into the ground and wide enough to prevent water flowing underneath or around the barrier.
6. Match the type and design of any geotextile barrier to the nature of sediment issue.
7. Regularly check the quality of water discharging from barriers and traps to ensure sediment is being removed, especially after heavy rainfall; maintain and adjust as necessary.
8. Temporarily divert flows or install a downstream silt trap when removing barriers or traps from watercourses; excavate any significant sediment deposits and dump silt outside buffer areas.

Figure 33a Large silt traps can hold more water and help to settle finer sediment but need care to avoid washout of bund, especially at outlet at high flow.

Figure 33b An example of a poorly designed silt trap: culvert aligned with outflow, promoting slip-streaming, while hanging inflow will generate turbulence and stir up sediment.

Figure 33c Coir matting can help trap fine and coarse sediment across a range of flows.

Figure 33d A collection of different sized stones can provide an effective drain-end sediment trap.

Figure 33e Terrain fabric can be used to create a small silt trap but is readily bypassed by significant flows.

Figure 33f Use timber posts at a slight upslope angle to support longer lengths of geotextile barrier. Consecutive barriers, as shown here, may be needed to manage a sediment pollution incident.

Operational practice for spillages

The actions described in the contingency plan should be implemented as soon as a spillage occurs. These can be summarised under the 'Assess, Communicate, Contain and Clean up' emergency action protocol.

Assess

- Quickly assess the site of the spillage and establish if there are any casualties or threats requiring the emergency services.
- Record the details of the location (GPS coordinates/grid reference), type and extent of the spill, and whether it has reached a watercourse.
- Assess any health and safety implications and the need for pollution control equipment.

Communicate

- Inform the local office and summon appropriate assistance if needed.
- Contact relevant personnel and organisations immediately (using the list of key contacts) if corrective action is required, and alert any neighbours likely to be affected.
- Consider using a specialist contractor with purpose-built equipment for recovering large oil spills, especially where the pollutant is well mixed within a watercourse.

Contain

!

Spill kits should contain absorbent materials to temporarily contain and soak up spillages. Larger stocks of materials and equipment should be kept packed and ready for use at key locations.

- Take action to stop further spillage, where it is safe to do so. This could involve placing an empty container or absorbent cushion under the source of a leak, repositioning leaking containers, or blocking the leak with suitable materials. If this is not possible or the spill is complete, focus attention on mopping up surface deposits and limiting further spread by using available materials and equipment.
- Trace the source of the spill if first recorded within a watercourse. The nature and amount of the contaminant will help to determine the best course of action (Figure 34). Most pesticides are highly soluble in water and extremely difficult to track and remove. Obtain advice from the water regulatory authority. Odour can be a useful indicator in determining how far a pollutant has travelled.

Figure 34 Oil-based substances are easier to detect and contain than water-soluble chemicals.

- Deal with diesel or oil spills in ditches, drains, and minor streams by creating a makeshift dam using soil or logs, and then apply absorbent materials to soak up the pollutant. Place absorbent sheets directly onto the contaminated water surface and replace when full, or wring out into a container and reuse in an emergency. Alternatively, if no synthetic materials are available, newspapers, paper towelling, wood chips, and sawdust have good absorbent qualities and can be used as a stop-gap measure.
- Build additional, better quality dams using wooden boards, stakes, sandbags, or straw bales, incorporating pipes to control water flows via surface or bottom routes. Such dams may need to remain in place for several weeks while the pollutant continues to drain from the soil and is removed using absorbent sheets. An alternative approach, especially on steep terrain and for spillages of pesticide, would be to block and divert the affected minor watercourse into a less sensitive area, onto unbroken ground, or into a holding pool, for later treatment.
- Spillages that have entered larger streams, rivers, and standing waters are more difficult to deal with and advice should be sought from the water regulatory authority. Containment is only really feasible for lighter oils such as diesel, where there is scope for limiting spread by using a series of absorbent booms. Tie the booms securely together in an overlapping pattern and anchor them to the bank to create an oil-tight seal. Deploy the booms at a slight angle to the direction of flow on streams and rivers, allowing the oil to concentrate into a recovery area.

Clean up

- Put all used absorbent materials in sealed heavy duty bags and remove from the site for disposal by a licensed waste disposal contractor.
- Dig up and bag contaminated soil ready for removal and disposal.
- Contact the water regulatory authority for advice on dealing with contaminated streamsides and sediments.

For significant spillages, water samples may need to be collected and analysed to check the spillage has been dealt with. The water regulatory authority will advise on the nature of sampling required and on qualified contractors to undertake the work.

Operational practice for fire-fighting chemicals

Fire-fighting chemicals can pollute water. Contamination by synthetic detergents or protein foams deoxygenates water and kills fish and other aquatic life. The spillage or careless disposal of foam presents the greatest risk. Particular care is therefore required in the storage, transport, handling, and application of these chemicals when reacting to emergency situations (Box 7).

Box 7 Fire-fighting chemicals

The Forestry Commission Practice Guide *Building wildfire resilience into forest management planning* sets out measures for planning and operational practice. You should:

- Identify suitable water sources for fire-fighting.
- Secure all containers during transport and ensure proper load distribution.
- Identify safe temporary storage and handling areas.
- When fighting fires ensure foam traces are laid down outside of buffer areas.
- Minimise stream crossings by machinery during fire-fighting operations.
- Liaise with the water regulatory authority about the disposal of premixed foam.

Monitoring

Monitor soil and water conditions during forestry operations to check for early signs of damage that could lead to water pollution. Ground damage is a precursor to soil erosion, which poses a particular risk of pollution where surface run-off can carry sediment to watercourses. Regular assessment will allow early intervention to address the source of the problem. Things to look for are the extent of ground damage, signs of erosion within cultivation channels, or expanding sediment deposits within drains and buffer areas.

Monitoring the general condition of water flowing within drains, streams, and rivers is a good indicator of site problems. Use a clear-sided bottle or container to check the clarity of water within any local watercourse receiving drainage from the site. This should be done daily on sites draining to water supplies or waters supporting protected or priority freshwater species and habitats. On other sites such checks should be done every few days, depending on the conditions. Problems are most likely to arise during wet periods and therefore it is important to check conditions during high flows after heavy rain. A simple assessment of the clarity of the sample by eye should suffice (Appendix 2). Keep a record of the time of sampling, nature of the weather, and a description of the appearance of the water.

Alterations in the clarity, colour, or odour of a watercourse require further examination (Figure 35). Changes can occur naturally in response to weather conditions, but it should be easy to discount these by comparing conditions with other local streams unaffected by forest operations. Immediate action should be taken in response to marked shifts in water quality such as a significant reduction in clarity, presence of an oil film, or any smell of chemicals. These issues should be traced upstream to identify the source. Action must be taken to remedy the cause, for example, by suspending operations, modifying operating procedures, and constructing silt traps (See Section 8). If the problem extends off site, the water regulatory authority and downstream water users must be notified (see Contingency Planning, page 35).

The impacts of some practices such as cultivation and drainage may not appear for a number of months after operations are completed. For example, it may not be until after a wet winter period or a significant rainfall event that a problem becomes evident. Thus a site check should be made between three and nine months after the completion of operations to determine if any erosion problems are developing within cultivation channels or drains.

Figure 35 Heavy rainfall has resulted in water overspilling from a drain into a lower cultivation channel, causing erosion and turbid water discharging into a watercourse.

Further reading and useful sources of information

Forestry Authority publications

Requirements and guidance

The UK Forestry Standard and its suite of supporting guidance is available from the Forest Research website at www.forestresearch.gov.uk/ukfs

- The UK Forestry Standard (FCFC001)
- Whole-tree harvesting: a guide to good practice (FCPG011)
- Managing brash on conifer clearfell sites (FCPN013)
- Building wildfire resilience into forest management planning (FCPG022)
- Managing forests in acid sensitive water catchments (FCPG023)
- Use of sewage sludges and composts in forestry (FCIN079)
- Extraction route trials on sensitive sites (FCTN010)
- Protecting the environment during mechanised harvesting operations (FCTN011)
- Creating and managing riparian woodland (UKFSPG028)

Research

Forestry Commission and Forest Research publications are available from the online publications catalogue at www.forestresearch.gov.uk/publications

- Cultivation of soils for forestry (FCBU119)
- Water use by trees (FCIN065)
- Environmental effects of stump and root harvesting (FCRN009)
- Forestry and surface water acidification (FCRN016)
- Ecosystem services and forest management (FCRN020)

Other publications

- Pollution Prevention Guidelines (Environmental Alliance)
  - Understanding your environmental responsibilities
  - Above ground oil storage tanks
  - Works and maintenance in or near water
  - Safe storage and disposal of used oils
  - Vehicle washing and cleaning
  - Managing fire water and major spillages
  - Pollution incident response planning
  - Incident response – dealing with spills

- Good Practice Guides (SEPA)
  - Bank protection
  - River crossings
  - Sediment management
  - Construction methods
  - Riparian vegetation management

- Road haulage of round timber code of practice (FISA – Forest Industry Safety Accord)

- Pesticides: Codes of practice for using plant protection products
  - England and Wales (Health and Safety Executive)
  - Scotland (Scottish Government)
  - Northern Ireland (Department of Agriculture, Environment and Rural Affairs)

Websites

UK forestry authorities (from 1 April 2019)

- England: Forestry Commission – www.gov.uk/ukfs
- Scotland: Scottish Forestry – www.forestry.gov.scot
- Wales: Natural Resources Wales – www.naturalresourceswales.gov.uk
- Northern Ireland: Forest Service – www.daera-ni.gov.uk/forestry

Water regulatory authorities

- England: Environment Agency – www.environment-agency.gov.uk
- Scotland: Scottish Environment Protection Agency – www.sepa.org.uk
- Wales: Natural Resources Wales – www.naturalresourceswales.gov.uk
- Northern Ireland: Northern Ireland Environment Agency – www.daera-ni.gov.uk/northern-ireland-environment-agency

Other useful websites

- Joint Nature Conservation Committee (JNCC) – jncc.defra.gov.uk
- Association of Drainage Authorities (ADA) – www.ada.org.uk (to find your lead local flood authority)
- Met Office – www.metoffice.gov.uk
- Natural England – www.naturalengland.org.uk
- NatureScot – www.nature.scot
- The Rivers Trust – www.theriverstrust.org (to find your local rivers trust)
- WaterUK – www.water.org.uk (to find your local water company)

Appendix 1: Pollution control checklist for spillages

Consider issuing a pollution control checklist to operators to remind them of good practice and the immediate actions to be taken in the event of a chemical or oil spillage in or near a watercourse.

Assess

• Is anyone injured?	✔	Apply **first aid** and summon the **emergency services** if needed.
• Is the scene safe?	✔	Consider **flash points** and **toxic fumes.**
• Where is the site?	✔	Note the **Grid reference** or **GPS coordinates.**
• What is the spillage?	✔	Record the **type**, **source,** and **extent** of the spill.
• What action is required?	✔	**Act to contain spillage.** If it is not possible, notify the agreed contacts and anyone at risk (e.g. downstream users).

Communicate

• Forestry site manager	✔	Mobile:
• Local forestry office	✔	Mobile:
• Out of hours contact	✔	Mobile:
• Neighbours/landowners	✔	Mobile:
• Downstream water users	✔	Mobile:

Contain

• Locate the source of spill if unknown	✔	Take action to stop the leak/prevent further spillage at source.
• Stop the spill from spreading	✔	Use available materials and equipment to create a barrier. Wear personal protective equipment if the spill is hazardous.
• Deal with spillage	✔	Use available absorbent materials and equipment from spill kit.
• Organise back-up materials/equipment	✔	Send for extra pollutant absorbing materials from nearest store.
• Assess effectiveness of actions	✔	Monitor site and condition of water.

Clean up

• Bag contaminated materials, including soil	✔	Remove contaminated materials from the site and dispose via a licensed waste disposal company.
• Check site and watercourse(s) are clean	✔	Discuss with the site manager whether water sampling is needed.
• Reinstate site when confirmed clean	✔	Dismantle and remove equipment and any containment measures.

Appendix 2: Assessing water turbidity

Water turbidity can be quickly and easily monitored to ensure site run-off is not causing pollution that could damage the freshwater environment or impact on water supplies.

The turbidity of a water sample is a good indicator of the fine sediment content and its measurement can be used to assess the impact of management practices and effectiveness of emergency measures. It can also be used to trace the source of pollution when someone first notices a change in water clarity.

Method

1. Fill a clear-sided and clean bottle from the watercourse, taking care not to touch the bottom of the channel to avoid disturbing any deposits of sediment, which can give a high reading.

2. Place the sample bottle against an appropriately coloured background and compare the clarity against the row of sample bottles below.

3. Record the turbidity measurement taken at each site visit in a notebook.

The drinking water standard is 4 NTU so any visible water turbidity is an issue for water supplies. Freshwater life can be adversely affected by turbidity levels of between 10 and 50 NTU so surface waters cloudier than this require attention to check whether forest operations are the cause.

Water turbidity is measured in Nephelometric Turbidity Units (NTUs) with an instrument called a nephelometer that uses a light beam.

0 NTU	50 NTU	100 NTU	200 NTU	300 NTU

Glossary

Abstraction point (water supply) The point at which water can be taken or diverted from the natural water environment (such as a river, stream, lake, borehole, or well) for a variety of uses (e.g. drinking, irrigation, or industrial application).

Acidification A continuing loss of acid-neutralising capacity manifested by increasing hydrogen ion concentration and/or declining alkalinity; the term may be applied to a catchment, waters, or soils.

Approval (pesticides) Chemical products, for which usage and methods of application have been approved by the UK Chemicals Regulation Division (of HSE).

Bearing capacity (soil) The capacity of soil to support the loads applied to the ground. The maximum average contact pressure between the load and the soil which should not produce shear failure in the soil.

Booms (oil spillage) Temporary floating barriers used to contain an oil spill. Booms help to concentrate oil in thicker surface layers so that skimmers and other recovery methods can be used more effectively.

Borrow pits An area of ground where material (usually soil, gravel or sand) has been excavated for use at another location.

Brash The residue of branches, leaves, and tops of trees, sometimes called 'lop and top', usually left on site following harvesting.

Brash bund An embankment built of brash used to control and filter the flow of water.

Buffer area An area of land which protects the watercourse from activities on the adjacent land, such as by intercepting polluted run-off. The buffer area will usually include the riparian zone and may extend into the adjacent land.

Catchment The area of land from which precipitation drains to a defined point in a river system, or to a lake, reservoir, or spring.

Compaction The compression of soil leading to reduced pore space, usually due to the weight of heavy machinery. Compacted soils become less able to absorb and transmit rainfall, thus increasing run-off and erosion.

Compliance Acting in accordance with an order, rule, set of standards, or request, particularly in accordance with the law. In the context of this Guide, the term 'compliance' refers to meeting the requirements of the UK Forestry Standard.

Cross-drains Drains that are aligned across a slope to collect and manage run-off from a site, particularly from cultivation channels.

Crossfall (roads and tracks) The transverse sloping of a road or track surface towards the shoulder or gutter on either side.

Cultivation Any method of soil disturbance to aid the establishment of trees.

Culvert A channel, pipe or tunnel used to convey water from one area to another, normally from one side of a road to the other.

Cut-off drains Drains aligned to intercept and divert water flowing onto a site from upslope land.

Debris flow A moving mass of loose mud, sand, soil, rock, water, and air that travels down a slope under the influence of gravity.

Dissolved organic carbon A broad classification for organic molecules of varied origin and composition dissolved in water within aquatic ecosystems. In general, organic carbon compounds are a result of decomposition processes from dead organic matter.

Dog-leg (timber extraction) A sharp bend in extraction routes designed to prevent the build-up of water flowing down and eroding routeways.

Drainage system A system of drains for collecting and conveying excess water from a site.

Establishment (period) The formative period which ends after young trees are of sufficient size so that, given adequate protection, they are likely to survive as woodland at the required stocking density.

Fish-spawning gravels Sorted, clean gravel patches (within watercourses) of a size appropriate for the needs of resident or migrating fish.

Flushes (groundwater seepage) Areas of wet ground formed by groundwater seepage.

Foam trace (fire fighting) A line of foam up to 15 m wide used to create a firebreak or widen an existing firebreak in order to stop the spread of wildfire.

General Binding Rules (GBRs) Part of the regulatory framework in Scotland with respect to water and applying to all types of rural land use. Under the Regulations, activities likely to have a significant adverse effect on the water environment need to be authorised proportionate to the level of risk posed to the environment. GBRs represent the lowest level of control and are designed to manage low-risk activities.

Geotextile barrier A permeable synthetic textile material used to filter sediment in run-off or to provide erosion control.

Good status (water) One of five classes of ecological status under the Water Framework Directive, the others being high, moderate, poor, and bad.

Gullying The creation of gullies by running water, eroding sharply into the soil and subsoil, typically on a hillside.

Hanging culvert A culvert with an outlet elevated above the downstream water surface.

Harvesting system The process by which timber is harvested. The three main systems are shortwood, tree length, and whole tree.

Head wall A concrete structure installed at the outlet of a drain or culvert that functions as a retaining wall to protect against erosion, or as a means to divert water flow.

Heavy rain Depicted by the Met Office and in BBC weather forecasts by a symbol showing a dark grey cloud with two raindrops.

Leaching The removal of soluble elements from one zone in soil to another via water movement in the profile.

Mole drain An underground channel made by a mole plough used for draining heavy soils of more or less uniform slope.

Mounding The process of forming a small mound of soil on which to plant a tree, thus increasing the aerobic zone of soil and maximising root extension. Mounds can be formed by excavators or continuous mounder machines. Excavator mounding is most common and can form three different types of mound. **Inverted mounds** place the soil back in the hole. **Hinge mounds** flip the soil over leaving one edge of the upper surface intact. **Trench mounds** (used mainly on restock sites) are created from soil dug from trenches (which may be filled with brash afterwards).

Natural angle of repose The angle of maximum slope at which a heap of any loose solid material (such as soil) will stand without sliding.

Nitrate leaching The removal of nitrate in solution from the soil via water movement, with the potential to contaminate surface water and groundwater.

Nutrient enrichment Excessive richness of nutrients in waters or soils which results in adverse effects on the diversity of the biological system, the quality of the water, and the uses to which the water may be put.

Offlet A step or pipe for intercepting/diverting run-off down harvesting routes to prevent soil erosion.

Patch scarification The discontinuous removal of surface humus to expose mineral soil, usually to depths of 15 cm in patches some 40 cm wide by 70 cm long and about 2 m apart.

pH A logarithmic index for the hydrogen ion concentration in an aqueous solution, used as a measure of acidity. A pH <7 is considered to be acidic and one >7 alkaline.

Priority freshwater species and habitats Species and habitats identified as being the most threatened and given statutory protection under country-based legislation linked to the UK Post-2010 Biodiversity Framework.

Road camber The cross-sectional slope over the width of a road, which can either be curved, straight or a combination of both. The purpose of camber is generally to drain rainwater from the road surface towards the edges.

Road dressing The use of a layer of granular-sized stone to cap and protect the road surface.

Scarifying Shallow (<15 cm) cultivation designed to create suitable positions for tree planting or a seed bed for natural regeneration.

Screefing Very shallow (<10 cm) form of cultivation involving the removal of herbaceous vegetation and soil organic matter to expose patches of bare soil for planting.

Seepage Water issuing from the ground in the form of flushes or springs.

Siltation Deposition of waterborne, mainly soil-derived, particles within a watercourse, other body of water, or wetland.

Silt trap A settling hole to encourage waterborne soil to settle out before the water enters a pond, drainage system or watercourse.

Soil complexes A mosaic of several soil types on one site.

Soil structure The combination or arrangement of primary soil particles into secondary units. The secondary units are characterised on the basis of size, shape, and grade (degree of distinctness).

Spoil trenches Trenches created by the excavation of soil to form cultivation mounds for tree planting, typically on restock sites.

Subsoiling Disturbing the soil at depth (e.g. 45–60 cm) to reduce obstructions to rooting caused by the presence of plough or iron pans, or induration.

Thatching (brash) The use of fresh brash to patch worn or damaged sections of timber extraction routes for soil protection.

Thinning The removal of a proportion of trees in a forest after canopy closure, usually to promote growth and greater value in the remaining trees.

Tile and stone drains Sub-surface drains formed from short lengths of concrete or ceramic pipes laid end to end to remove excess water from agricultural soils.

Tine slot The groove left in the soil by the tine sock at the base of the blade of a plough.

Water body The basic water management unit defined under the Water Framework Directive for which environmental objectives are set. Water bodies can be parts of rivers, lakes and estuaries, stretches of coastal water, or distinct volumes of groundwater.

Watercourse Any natural or man-made channel through which water flows continuously or intermittently.

Wetlands Transitional areas between wet and dry environments, ranging from permanently or intermittently wet land to shallow water and water margins. The term can describe marshes, swamps and bogs, some shallow waters, and the intertidal zone. When applied to surface waters, it is generally restricted to areas shallow enough to allow the growth of rooted plants.

Wheel chains Specialised chain links and/or rings fitted over bare tyres to provide additional traction and tyre protection.

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Trees and woodlands benefit the water environment in a number of ways. They protect aquatic habitats and species, preserve the quality of drinking water, alleviate flooding, and guard against erosion, landslides and the loss of soil. It is vital that we manage our forests, woodlands and trees sustainably to protect these environmental goods and services. Many forest management practices can impact on the water environment as a result of soil and vegetation disturbance or by altering the pathways of water movement. Poor forest management can diminish or reverse the benefits provided by forests and woodlands, contribute to local flooding and risk severe water pollution. This Practice Guide provides advice to forest managers, practitioners, planners and supervisors, on how forest operations should be planned and managed to protect the water environment. Applying this guidance will help ensure that forest operations comply with the UK Forestry Standard Guidelines on Forests and Water, which are the primary source of information on the legal and good practice requirements.

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